CHEMICAL ESSAYS.

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NOtwithſtanding what I had ſaid, in the concluſion of the Preface to the Fourth Volume of my Chemical Eſſays, concerning the little likelihood of the Tracts there mentioned being acceptable to many readers, my Bookſeller has deſired leave to publiſh them. He has formed an expectation, that the purchaſers of the Chemical Eſſays will not be diſpleaſed at having an opportunity of poſſeſſing all that remains of what I have ever written on chemical ſubjects. Great improvements have been made in

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many branches of chemiſtry ſince the *Inſtitutiones Metallurgicæ*, and the Plan of Chemical Lectures, were firſt printed, but I have no inclination to reviſe them; they will be candidly read with a reference to the time when they were compoſed. I do not recollect what motive induced me to write the Metallurgic Inſtitutes in Latin, unleſs it was the vanity of thinking, that when I had treated the other parts of Chemiſtry in the ſame manner, the work might ſtand a chance of finding its way into foreign countries. I had written ſeveral chapters *de Aere communi-fixo-inflammabili*; *de Igne*; *de Aqua*; *de Terra calcaria, vitreſcibili*, &c. much about the

period

period in which the Metallurgic Inſtitutes were finiſhed: but my attention being ſoon after called to other purſuits, I gave up the deſign which I had formed, of expreſſing in a connected ſeries of propoſitions what was then ſcientifically known in Chemiſtry; and what I had written, with this view, ſhared the fate of my other chemical manuſcripts, when I determined laſt year to quit this favourite ſtudy.

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ESSAY I.

Observations on the Sulphur Wells at HARROGATE, *made in July and August*, 1785.

IN 1733, when Doctor SHORT first published his Treatise on Mineral Waters, there were only three sulphur wells at Harrogate; there are now four. I made some inquiry respecting the time and occasion of making the fourth well, and received the following account from an old man, who was himself principally concerned in the transac-

 tion.

tion. About forty years ago, a person who, by leafe from the Earl of *Burlington*, had acquired a right of fearching for minerals in the foreft of Knarefborough, made a fhew as if he had a real intention of digging for coal, on the very fpot where the three fulphur wells were fituated. This attempt alarmed the apprehenfions of the inn-keepers and others at Harrogate, who were interefted in the prefervation of the wells: they gave him what legal oppofition they could, and all the illegal that they durft. At length, for the fum of one hundred pounds, which they raifed amongft themfelves, the difpute was compromifed, and the defign real or pretended of digging for coal was abandoned. Sulphur water, however, had rifen up where he had begun to dig. They inclofed the place

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with a little ſtone edifice, and putting down a baſon, made a fourth well. By a clauſe in the act of parliament for incloſing Knareſborough Foreſt, paſſed in 1770, it is rendered unlawful for any perſon whatever to ſink any pit, or dig any quarry or mine, whereby the medicinal ſprings or waters at Harrogate may be damaged or polluted; ſo that no attempts of the kind above mentioned need be apprehended in future.

This fourth well is that which is neareſt to one of the barns of the Crown-Inn, being about ten yards diſtant from it. In digging, a few years ſince, the foundation of that barn, they met with ſulphur water in ſeveral places. At a very little diſtance from the four wells there are two others of the ſame kind; one in the yard of the Half-Moon-Inn, diſ-

covered in digging for common water in 1783, and another which breaks out on the ſide of the rivulet below that Inn. On the banks of that rivulet I ſaw ſeveral other ſulphureous ſprings: they are eaſily diſtinguiſhed by the blackneſs of the earth over which they flow.

On the declivity of a hill, about a quarter of a mile to the weſt of the ſulphur wells at Harrogate, there is a bog which has been formed by the rotting of wood: the earth of the rotten wood is in ſome places four feet in thickneſs, and there is a ſtratum conſiſting of clay, and ſmall looſe decaying ſand-ſtones, every where under it. The hill above is of grit-ſtone. In this bog there are four more ſulphur wells; one at the top, near the rails which ſeparate the bog from the Common; and three

at the bottom, though one of these, strictly speaking, is not in the bog, but at the side of it in the stratum on which the bog is situated, and at the distance of a yard or two from a rivulet of fresh water, which runs from thence to Low Harrogate, passing close to the side but above the level of the sulphur wells of that place. On the other side of the hill, above the bog, and to the west of it, there is another sulphur well on the side of a brook; and it has been thought that the wells both at Harrogate and in the bog are supplied from this well. In a low ground, between High Harrogate and Knaresborough, there is a sulphur well; another to the north of it in Bilton Park, at about the distance of a mile; and another to the south of it, at a less distance, was discovered this

year in digging for common water by a perſon of the name of *Richardſon*; and, laſtly, there is another at a place called Hookſtone Crag: none of theſe laſt-mentioned wells are above two miles diſtant from High Harrogate; and by an accurate ſearch a great many more might, probably, be diſcovered in the neighbourhood.

It is not unuſual to dig within a few yards of any of theſe ſulphur wells, and to meet with water which is not ſulphureous. I ordered a well to be dug in the fore-mentioned bog, ſixteen yards to the ſouth of the ſulphur well which is near the rails, and to the ſame depth with it; the water with which it was preſently filled was chalybeate, but in no degree ſulphureous. I had another well dug, at about thirty yards diſtance from the three ſulphur wells which

which are ſituated at the lower extremity of the bog; this well, by the declivity of the ground, was ten or twelve feet below their level, but its water was not ſulphureous. From the firſt well which I dug, it is evident, that every part of the bog does not yield ſulphur water; and from the ſecond, which was ſunk into the clay, it is clear that every part of the ſtratum on which the bog is placed does not yield it, though one of the wells is ſituated in it.

The ſulphur wells at Harrogate are a great many feet below the level of thoſe in the bog; but they communicate with them, if we may rely on what Doctor *Short* has told us— " That about the beginning of this century, when the concourſe of people was very great to the Spaw at Harrogate, one *Robert Ward*, an old

man, made a bason in the clay under the moss of a bog where the strongest and briskest of these sulphur springs rise, and gathered half an hogshead of water at a time for the use of the poor; but when he laded this he almost dried the three sulphur wells at the village; whence it is evident, that all have the same origin, and communicate with one another." By conversing with some of the oldest and most intelligent people at Harrogate, I could not find that they entertained any opinion of the water at the bog having a communication with that at the Spaw. This circumstance might easily be ascertained; and, if the fact should be contrary to what Doctor *Short* supposed, the wells at the bog ought to be covered from the weather as those at the village are; they would by this mean

yield

yield great plenty of water for the baths which are wanted by invalids, and which are often very ſcantily ſupplied by the wells at Harrogate, notwithſtanding the attention which is uſed in preſerving the water which ſprings at the four wells, by emptying them as often as they become full during both the day and night time. And indeed it is ſurpriſing, that the well on the ſide of the rivulet below the Half-Moon-Inn, which is ſo well ſituated for the purpoſe, has never been incloſed for the furniſhing ſulphureous water for the baths. The preſent mode of carrying the water in caſks to the ſeveral houſes where the perſons lodge who want to bathe in it, is very troubleſome, and the water thereby loſes of its virtue. Some of the wells about the village, that for inſtance which has been

diſcovered

discovered at the Half-Moon-Inn, the water of which, I believe, springs from a different source from that which supplies the four sulphur wells, should be either enlarged to a greater horizontal breadth, or sunk to a greater depth, in order to try, by one or both of these ways, whether the quantity and strength of the water might not be increased: and if that should, as it probably would be the case, one or more baths might be erected after the manner of those at Buxton and other places; or, by proper additional buildings, warm bathing in sulphureous water might be practised, as is done in common water in the bagnios in London. The saltness of the sulphureous water, if that should be thought useful, might easily be made even greater than that of sea water, by adding a quarter

of

of a pound of common ſalt to every gallon of the water uſed in forming a bath. The waters at Harrogate, though they have long been very beneficial, have not yet been rendered ſo uſeful to mankind, as an intelligent and enterpriſing perſon might make them. The alternate ſtrata of ſand, ſtone, and ſhale, which compoſe the lower hills near the wells at Harrogate, dip very much, as may be ſeen in a ſtone quarry about two hundred yards from the wells; and the ſame circumſtance may be obſerved in dry weather, in following the bottom of the brook from the village up to the bog; and hence, if there be a communication between the waters of the bog and of the village, as Doctor Short aſſerts, it is probable, that the ſame ſtratum of ſhale which is ſeen at the

bottom

bottom of the wells at the village, breaks out again at the bog above the village, and that the water finds its way from the bog to the village through the crevices of that ſtratum.

After having obſerved, as carefully as I could, the number and ſituation of the ſulphur wells about Harrogate, I took notice of the temperature of the four at the village. In the month of June, 1780, when the thermometer in the ſhade was 72°, and the pump water at the Granby-Inn, the well of which is fifty feet deep, was 48°, the ſtrongeſt of the ſulphur wells, being that of which invalids uſually drink, was 50°. On the 29th of July in this year, after the earth had been parched with drought for many months, the heat of the ſtrongeſt well was 54°; the water

water of the Granby pump was on the ſame day 48°, and the heat of the air in the ſhade 76°. Doctor WALKER, who has lately written a treatiſe on Harrogate water, ſays, that the heat of this ſpring was 48°, when that of an adjoining rivulet was 53°. And I have little doubt in believing, that if the experiment was made in cold weather, the temperature of the ſame well would be found to be ſeveral degrees below 48. This variation of temperature in the ſulphur water indicates its ſpringing from no great depth below the ſurface of the earth; or at leaſt it indicates its having run for a conſiderable diſtance in a channel ſo near to the ſurface of the earth, as to participate of the changes of temperature to which that is liable from the action of the ſun. But the heat of the

ſulphur

ſulphur water is not only variable in the ſame well, at different times, but it is not the ſame in all the wells at the ſame time. If we call the ſtrongeſt well the firſt, and reckon the reſt in order, going to the right, the third well, which is reckoned the next ſtrongeſt, was 57° hot when the firſt well was 54°. In ſupport of the conjecture that the ſulphur water of the ſtrongeſt well would in a cold ſeaſon make the thermometer ſink below 48°, which is the conſtant temperature of ſprings ſituated at a great depth in the earth in this country, it may be obſerved, that though the firſt and the third well are never frozen, yet the ſecond and fourth well are frozen in ſevere weather. When the ſecond and the fourth well are covered with ice, it is probable, that the firſt and the third have a tempe-

rature far below 48°; but that the sea salt, which is more abundant in them than in the other two wells, and which of all salts resists most powerfully the congelation of the water in which it is dissolved, preserves them from being frozen in the coldest seasons incident to our climate.

As the temperature of these four wells is not the same in all of them at the same time, nor invariable in any of them, so neither does there seem to be any uniformity or constancy in them, with respect to the quantity of salt which they contain. The salt with which they are all impregnated is of the same kind in all, and it is almost wholly common salt; and though the quantity contained in a definitive portion of any one of the wells is not, I think, precisely the

ſame at all ſeaſons of the year, yet the limits within which it varies are not, I apprehend, very great. A method is mentioned in the LXth volume of the Philoſophical Tranſactions, of eſtimating the quantity of common ſalt diſſolved in water, by taking the ſpecific gravity of the water: this method is not to be relied on, when any conſiderable portion of any other kind of ſalt is diſſolved along with the ſea ſalt; but it is accurate enough to give a good notion of the quantity contained in the different wells at Harrogate. On the 13th of Auguſt, after ſeveral days of rainy weather, I took the ſpecific gravities of the four ſulphur wells at the village, the drinking well being the firſt.—Rain water 1.000; firſt well 1.009; ſecond well 1.002; third well 1.007; fourth

 well

well 1.002. By comparing theſe ſpecific gravities with the table which is given in the LXth volume of the Tranſactions, it may be gathered, that the water of the firſt well contained $\frac{1}{72}$ of its weight of common ſalt; that of the ſecond and fourth, $\frac{1}{236}$; and that of the third, $\frac{1}{84}$. After four days more heavy rain I tried the ſtrongeſt well again, and found its ſpecific gravity to be 1.008. It is worthy of obſervation, that the water, as it ſprings into the firſt and third well, is quite tranſparent, but uſually of a pearl colour in the ſecond and fourth, ſimilar in appearance to the water of the firſt or third well after it has been expoſed a few hours to the air; hence it is probable, that the external air has acceſs to the water of the ſecond and fourth well before it ſprings up into the

baſon. A great many authors have publiſhed accounts of the quantity of common ſalt contained in a gallon of the water of the ſtrongeſt well; they differ ſomewhat from each other, ſome making it more, others leſs, than two ounces. Theſe diverſities proceed either from the different care and ſkill uſed in conducting the experiment; or from a real difference in the quantity of ſalt with which the water is impregnated at different ſeaſons of the year. The medium quantity of ſalt contained in a gallon falls ſhort of, I think, rather than exceeds two ounces. The ſea water at Scarborough contains about twice as much ſalt as is found in the ſtrongeſt ſulphur well at Harrogate. The ſulphur wells at the bog are commonly ſaid to be ſulphureous, but not ſaline. This,

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however, is a miſtake; they contain ſalt, and ſalt of the ſame kind as the wells at the village. I could not diſtinguiſh the kind of ſalt by the method in which I had eſtimated the quantity contained in the ſulphur wells; I therefore evaporated a gallon of the water of the well in the bog which is near the rails, and obtained a full ounce of common ſalt, of a browniſh colour: the colour would have gone off by calcination. In what degree the medicinal powers of Harrogate water depend on its ſulphureous, and in what degree on its ſaline impregnation, are queſtions which I meddle not with: I would only juſt obſerve on this head, that any ſtrong ſulphureous water, ſuch as that of Keddleſtone in Derbyſhire, or of Shap in Weſtmoreland, which naturally contains little

or no sea salt, may be rendered similar to Harrogate water, by dissolving in it a proper proportion of common salt. The four sulphur wells at Harrogate are very near to each other; they might all be included within the circumference of a circle of seven or eight yards in diameter; yet, from what has been said it is evident, that they have not all either the same temperature, or the same quantity of saline impregnation. This diversity of quality, in wells which have a proximity of situation, is no uncommon phænomenon; and though at the first view it seems to be surprising, yet it ceases to be so on reflection: for the waters which feed wells so circumstanced, may flow through strata of different qualities situated at different depths, though in the same direction; or

through

through ſtrata placed both at different depths, and in different directions; and that this is the caſe at Harrogate is probable enough, there being hills on every ſide of the hollow in which the village is placed.

With reſpect to the ſulphureous impregnation of theſe waters, I made the following obſervations.

The inſide of the baſon, into which the water of the ſtrongeſt well riſes, is covered with a whitiſh pellicle, which may be eaſily ſcraped off from the grit-ſtone of which the baſon is made. I obſerved, in the year 1780, that this pellicle on a hot iron burned with the flame and ſmell of ſulphur. I this year repeated the experiment with the ſame ſucceſs; the ſubſtance ſhould be gently dried before it is put on the iron. I would further obſerve, that the ſulphur is

but a ſmall part of the ſubſtance which is ſcraped off. That I might be certain of the poſſibility of obtaining true palpable ſulphur from what is ſcraped off from the baſon, and at the ſame time give ſome gueſs at the quantity of ſulphur contained in it, I took three or four ounces of it, and having waſhed it well, and dried it thoroughly by a gentle heat, I put two ounces into a clean glaſs retort, and ſublimed from it about two or three grains of yellow ſulphur. This ſulphur, which ſtuck to the neck of the retort, had an oily appearance; and the retort, when opened, had not only the ſmell of the volatile ſulphureous acid, which uſually accompanies the ſublimation of ſulphur, but it had alſo the ſtrong empyreumatic ſmell which peculiarly appertains to burnt oils; and it retained

tained this ſmell for ſeveral days. It has been remarked before, that the ſalt ſeparable from the ſulphur water was of a browniſh colour; and others, who have analyſed this water, have met with a brown ſubſtance, which they knew not what to make of; both which appearances may be attributed to the oil, the exiſtence of which was rendered ſo manifeſt by the ſublimation here mentioned. I will not trouble the Society with any conjectures concerning the origin of this oil, or the medium of its combination with water; the diſcovery of it gave me ſome pleaſure, as it ſeemed to add a degree of probability to what I had ſaid concerning the nature of the air with which, in one of my Chemical Eſſays, I had ſuppoſed Harrogate water to be impregnated. I will again take the

liberty of repeating the query which I there propofed. "Does this air, and the inflammable air feparable from fome metallic fubftances, confift of *oleaginous* particles in an elaftic ftate?" When I ventured to conjecture, in the Effay alluded to, that fulphureous waters received their impregnation from air of a particular kind, I did not know that Profeffor *Bergman* had advanced the fame opinion, and denominated that fpecies of air, Hepatic Air. I have fince then feen his works, and very readily give up to him not only the priority of the difcovery, but the merit of profecuting it. And though what he has faid concerning the manner of precipitating fulphur from thefe waters can leave no doubt in the mind of any chemift concerning the actual exiftence of fulphur in them; yet

yet I will proceed to the mention of ſome other obvious experiments on the Harrogate water, in ſupport of the ſame doctrine.

Knowing that, in the baths of Aix-la-Chapelle, ſulphur is found ſticking to the ſides and top of the channel in which the ſulphureous water is conveyed, I examined with great attention the ſides of the little ſtone building which is raiſed over the baſon of the ſtrongeſt well, and ſaw them in ſome places of a yellowiſh colour: this I thought proceeded from a ſpecies of yellow moſs, commonly found on grit-ſtone: I collected, however, what I could of it by bruſhing the ſides of the building, at the diſtance of three or four feet from the water in the baſon: on putting what I had bruſhed off on a hot iron, I found that it conſiſted

ſiſted principally of particles of grit-ſtone, evidently however mixed with particles of ſulphur.

Much of the ſulphureous water is uſed for baths at Harrogate; and for that purpoſe all the four wells are frequently emptied into large tubs containing many gallons apiece; theſe conſtantly ſtand at the wells, and the caſks, in which the water is carried to the ſeveral houſes, are filled from them. On examining the inſides of theſe tubs, I found them covered, as if painted, with a whitiſh pellicle. I ſcraped off a part of this pellicle: it was no longer ſoluble in water; but, being put on a hot iron, it appeared to conſiſt almoſt wholly of ſulphur. Some of theſe tubs have been in uſe many years, and the adhering cruſt is thick in proportion to the time they have

been

been applied to the purpose; but the sulphur pellicle was sufficiently observable on one which was new in the beginning of this season. The water when it is first put into these tubs is transparent; when it has been exposed to the air for a few hours, it becomes milky; and, where the quantity is large, a white cloud may be seen slowly precipitating itself to the bottom. This white precipitate consists partly, I am not certain that it consists wholly, of sulphur; and the sulphur is as really contained in the waters denominated sulphureous, as iron is contained in certain sorts of chalybeate waters; in the one case the iron is rendered soluble in water by its being united to fixed air, or some other volatile principle; and in the other sulphur is rendered soluble in water by its being united

to fixed air, or ſome other volatile principle: neither iron nor ſulphur are of themſelves ſoluble in water, but each of them, being reduced into the form of a ſalt by an union with ſome other ſubſtance, becomes ſoluble in water, and remains diſſolved in it, till that other ſubſtance either eſcapes into the air, or becomes combined with ſome other body.

About forty years ago, they took up the baſon of the third well, and a credible perſon, who was himſelf preſent at the operation, informed me, that in all the crevices of the ſtone on which the baſon reſted, there were layers of pure yellow ſulphur. This I can well believe, for I ordered a piece of ſhale to be broken off from the bottom of the fourth well; it was ſplit, as ſhale generally is,

is, into ſeveral thin pieces, and was covered with a whitiſh cruſt. Being laid on a hot iron, in a dark room, it cracked very much, and exhibited a blue flame and ſulphureous ſmell.

If the water happens to ſtand a few days in any of the wells, without being diſturbed, there is found at the bottom a black ſediment; this black ſediment alſo marks the courſe of the water which flows from the well, and it may be eſteemed characteriſtic of a ſulphur water. The ſurface of the water alſo, when it is not ſtirred for ſome time, is covered with a whitiſh ſcum. Doctor *Short* had long ago obſerved, that both the black ſediment, and the white ſcum, gave clear indications, on a hot iron, of their containing ſulphur: I know not whence it has come that his accuracy has been queſtioned in

this

this point; certain I am, that on the repetition of his experiments I found them true. The white ſcum alſo, which is found ſticking on the graſs over which the water flows, being gently dried, burns with the flame and ſmell of ſulphur. From what has been ſaid it is clear, that ſulphur is found at Harrogate, ſticking to the baſon into which the water ſprings; ſublimed upon the ſtones which compoſe the edifice ſurrounding the well; adhering to the ſides of the tubs in which the water ſtands; ſubſiding to the bottom of the channel in which the water runs; and covering the ſurface of the earth, and of the blades of graſs, over which it flows. It is unneceſſary to add another word on this ſubject; it remains that I riſk a conjecture or two, on the primary cauſe of the

ſulphureous

ſulphureous impregnation obſervable in theſe waters.

In the Chemical Eſſay before referred to, I have ſhewn, that the air ſeparable from the lead ore of Derbyſhire, or from Black-Jack, by ſolution in the acid of vitriol, impregnates common water with the ſulphureous ſmell of Harrogate water; and I have alſo ſhewn that the bladder fucus or ſea-wrack, by being calcined to a certain point, and put into water, not only gives the water a brackiſh taſte, but communicates to it, without injuring its tranſparency, the ſmell, taſte, and other properties of Harrogate water. Profeſſor *Bergman* impregnated water with a ſulphureous taſte and ſmell, by means of air ſeparated by the vitriolic acid from hepar ſulphuris, made by fuſion of equal weights of

ſulphur

ſulphur and pot-aſhes, and from a maſs made of three parts of iron filings melted with two of ſulphur; and he found alſo, that Black-Jack and native Siberian iron yielded hepatic air, by ſolution in acids. This, I believe, is the main of what is known by chemiſts on this ſubject; what I have to ſuggeſt, relative to the Harrogate waters in particular, may perhaps be of uſe to future inquirers.

I have been told, that on breaking into an old coal-work, in which a conſiderable quantity of wood had been left rotting for a long time, there iſſued out a great quantity of water ſmelling like Harrogate water, and leaving, as that water does, a white ſcum on the earth over which it paſſed. On opening a well of common water, in which there was

found a log of rotten wood, an obſervant phyſician aſſured me, that he had perceived a ſtrong and diſtinct ſmell of Harrogate water. Dr. *Darwin*, in his ingenious Account of an artificial Spring of Water, publiſhed in the firſt part of the LXXVth volume of the Philoſophical Tranſactions, mentions his having perceived a ſlight ſulphureous ſmell and taſte in the water of a well which had been ſunk in a black, looſe, moiſt earth, which appeared to have been very lately a moraſs, but which is now covered with houſes built upon piles. In the bog or moraſs above mentioned there is great plenty of ſulphureous water, which ſeems to ſpring from the earth of the rotten wood of which that bog conſiſts. Theſe facts are not ſufficient to make us certain,

that rotten wood is efficacious in impregnating water with a ſulphureous ſmell; becauſe there are many bogs in every part of the world, in which no ſulphureous water has ever been diſcovered. Nor, on the other hand, are they to be rejected as of no uſe in the inquiry; becauſe wood, at a particular period of its putrefaction, or when ſituated at a particular depth, or when incumbent on a ſoil of a particular kind, may give an impregnation to water, which the ſame wood, under different circumſtances, would not give.

The bilge water, uſually found at the bottom of ſhips which are foul, is ſaid to ſmell like Harrogate water: I at firſt ſuppoſed, that it had acquired this ſmell in conſequence of becoming putrid in contact with

the timber on which it refted, and this circumftance I confidered as a notable fupport to the conjecture I had formed of rotten wood being, under certain circumftances, inftrumental in generating the fmell of Harrogate water. But this notion is not well founded; for the bilge water is, I fuppofe, falt water; and Dr. *Short* fays, that fea water, which had been kept in a ftone bottle fix weeks, "ftunk not much fhort of Harrogate fulphur water." It has been remarked above, that calcined fea-wrack, which contains a great deal of fea falt, exhales an odour fimilar in all refpects to that of Harrogate water; and in confirmation of the truth of this remark, I find that an author, quoted by Dr. *Short*, fays, that "Bay falt thrice calcined, diffolved in water, gives exactly the

odour of the ſulphur well at Harrogate." From theſe experiments conſidered together, it may, perhaps, be inferred, that common ſalt communicates a ſulphureous ſmell to water both by putrefaction and calcination. Hence ſome may think, that there is ſome probability in the ſuppoſition, that either a calcined ſtratum of common ſalt, or a putreſcent ſalt ſpring, may contribute to the production of the ſulphureous ſmell of Harrogate water; eſpecially as theſe waters are largely impregnated with common ſalt. However, as neither the ſalt in ſea water, nor that of calcined ſea-wrack, nor calcined bay ſalt, are any of them abſolutely free from the admixture of bodies containing the vitriolic acid, a doubt ſtill remains, whether the ſulphureous exhalation, here

ſpoken

ſpoken of, can be generated from ſubſtances in which the vitriolic acid does not exiſt.

The ſhale from which alum is made, when it is firſt dug out of the earth, gives no impregnation to water; but by expoſure to air and moiſture its principles are looſened, it ſhivers into pieces, and finally moulders into a kind of clay, which has an aluminous taſte. Alum is an earthy ſalt reſulting from an union of the acid of ſulphur with pure clay; and hence we are ſure, that ſhale, when decompoſed by the air, contains the acid of ſulphur; and from its oily black appearance, and eſpecially from its being inflammable, we are equally certain that it contains phlogiſton, the other conſtituent part of ſulphur. And indeed pyritous ſubſtances, or combinations

of ſulphur and iron, enter into the compoſition of many, probably of all ſorts of ſhale, though the particles of the pyrites may not be large enough to be ſeen in ſome of them; and if this be admitted, then we need be at no loſs to account for the bits of ſulphur, which are ſublimed to the top of the heaps of ſhale, when they calcine large quantities of it for the purpoſe of making alum: nor need we have any difficulty in admitting, that a phlogiſtic vapour muſt be diſcharged from ſhale, when it is decompoſed by the air. Dr. *Short* ſays, that he burned a piece of aluminous ſhale for half an hour in an open fire; he then powdered and infuſed it in common water, and the water ſent forth a moſt intolerable ſulphureous ſmell, the very ſame with Harrogate water. He burned

ſeveral

ſeveral other pieces of ſhale, but none of them ſtunk ſo ſtrong as the firſt. This difference may be attributed, either to the different qualities of the different pieces of ſhale which he tried, or to the calcination of the firſt being puſhed to a certain definite degree; for the combination of the principles on which the ſmell depends may be produced by one degree of heat, and deſtroyed by another. I have mentioned, briefly, theſe properties of ſhale, becauſe there is a ſtratum of ſhale extended over all the country in the neighbourhood of Harrogate; ſeveral beds of it may be ſeen in the ſtone quarry above the ſulphur wells; many of the brooks about Harrogate run upon ſhale, and the ſulphur wells ſpring out of it. They have bored to the depth of twenty yards into

this ſhale, in different places, in ſearch of coal, but have never penetrated through it. Its hardneſs is not the ſame at all depths. Some of it will ſtrike fire, as a pyrites does, with ſteel; and other beds of it are ſoft, as if in a ſtate of decompoſition, and the ſulphur water is thought to riſe out of that ſhale which is in the ſofteſt ſtate. But whatever impregnation ſhale when calcined, or otherwiſe decompoſed to a particular degree, may give to the water which paſſes over it, it muſt not be concluded, that ſhale in general gives water a ſulphureous impregnation; ſince there are many ſprings, in various parts of England, ariſing out of ſhale, in which no ſuch impregnation is obſerved.

I forgot to mention, in its proper place, that having viſited the bog,

ſo often ſpoken of, after a long ſeries of very dry weather, I found its ſurface, where there was no graſs, quite candied over with a yellowiſh cruſt, of tolerable conſiſtency, which had a ſtrong aluminous taſte, and the ſmell of honey. *Bergman* ſpeaks of a turf found at Helſingberg in Scania, conſiſting of the roots of vegetables, which was often covered with a pyritous cuticle, which, when elixated, yielded alum; and I make no doubt, that the Harrogate moraſs is of the ſame kind.

Whether nature uſes any of the methods which I have mentioned of producing the air by which ſulphureous waters are impregnated, may be much queſtioned; it is of uſe, however, to record the experiments by which her productions may be imitated; for though the line of

human

human underſtanding will never fathom the depths of divine wiſdom, diſplayed in the formation of this little globe which we inhabit; yet the impulſe of attempting an inveſtigation of the works of God is irreſiſtible; and every phyſical truth which we diſcover, every little approach which we make towards a comprehenſion of the mode of his operation, gives to a mind of any piety the moſt pure and ſublime ſatisfaction.

ESSAY II.

Experiments and Obſervations on various Phænomena attending the Solution of Salts.

HAVING lately had occaſion, in ſome chemical inquiries, to make various ſolutions of ſalts, I met with ſome phænomena, which did not appear to me either to have been ſufficiently attended to, or conſiſtently explained by writers upon that ſubject. The ſuſpenſion of ſalts in water, of metals in acids, of ſulphur in oils, and of other bodies in menſtruums ſpecifically lighter than the bodies themſelves, hath ever

ever been confidered in chemiftry, as a problem of difficult folution. Thofe philofophers who acquiefce, upon the whole, in the caufe which hath been affigned for this phænomenon by Sir Ifaac Newton, in his Optical Queftions, have taken great pains to illuftrate the manner how it is effected, by fuppofing that the bodies are received into the pores of their refpective menftruums, and there kept fufpended by the attraction or, as Bernouilli and Freind would have it, by the refiftance arifing from the tenacity of the fluid. Hence it happens, fay thefe philofophers, that after water is faturated with one falt, it is ftill capable of diffolving fomewhat of a fecond kind, and being faturated with that, of a third, and fo on; juft as a veffel filled as full as poffible with fpheres

or cylinders of one magnitude hath a capability of receiving similar bodies of an inferior size, or bodies of a different figure. The opinion of Gassendus seems to have been generally adopted; he endeavours to prove, from the experiment which hath been mentioned, not only the porosity of water, but a diversity in the figures of the pores: *Affero & aliud experimentum singulare, quo visus sum mihi deprehendere interspersa hujusmodi spatiola inania intra aquam dari.—Aiebam, cum sint salis corpuscula cubica, poterunt ea quidem replere spatiola, quæ & ipsa cubica fuerint; at cum non modo commune sal, sed alumen etiam, quod est octahedricum, halinitrum item, & sal ammoniacum saccharumque & alia quæ aliarum sunt figurarum eâdem aquâ exsolvi possunt; erunt ergo etiam in aqua*

aqua spatiola octahedrica atque id genus alia; adeo ut aqua, tametsi sale saturata fuerit, nihilominus & alumen et cetera omnia exsolvere possit ac in sese transfundere. Gas. Phys. l. i. sect. 1. cap. iii. The reason why warm water dissolves in general more salt than cold water, seems as if it might be derived from the same principle, was it true; the interstices between the elementary particles of water are enlarged by the expansion of the fluid, and might therefore be supposed capable of admitting into them a larger quantity of salt. This doctrine hath been embraced by most philosophers, especially by the late Abbé Nollet, in the 4th volume of his Leçons de Physique; and I do not know that it hath been opposed by any body. The late Mr. Eller, of Berlin, hath carried this speculation

ſpeculation ſo far, as to publiſh a Table in the Berlin Memoirs for 1750, exhibiting the ſeveral quantities of above twenty different kinds of ſalt, which a given quantity of water will abſorb into its pores, without being in the leaſt augmented in bulk. It is not therefore without ſome uneaſineſs that I find myſelf conſtrained to diſſent from the general opinion, and particularly to differ from Mr. Eller, who hath treated this ſubject *ex profeſſo*; who made his experiments, as he himſelf aſſures us, with the greateſt exactneſs; and who was led by them to the diſcovery of what he is pleaſed to call, *une vérité inconteſtable, ſavoir, que les plus petites parties conſtituantes de l'eau ſont doüées de pores ou d'interſtices dans leſquels les atomes de ſel peuvent nicher, ſans augmenter leur*

leur volume. I do not at preſent ſee any very probable method of reconciling the different reſults of our inquiries; I will therefore content myſelf with giving a plain relation of the experiments which I have made upon this ſubject.

EXPERIMENT I.

I took a large matraſs, containing, when filled to the middle of its neck, 132 ounces of water, troy weight; the diameter of the cavity of the neck was ſix lines · having with a diamond marked the place where the water ſtood in the neck of the matraſs, I dropped into it a ſingle piece of purified nitre, the weight of which was a 2600th part of the weight of the water, and immediately obſerved that the water was conſiderably elevated in the tube;

during the ſolution of ſalt, the water ſunk near one third of its whole elevation; but when the ſolution was entirely finiſhed, it remained very ſenſibly raiſed above the mark: ſo that, even from the experiment with this inſtrument, we may be aſſured that water cannot abſorb $\frac{1}{1000}$th part of its weight of nitre, without being augmented in bulk. Mr. Eller, from his experiments, concludes, that eight ounces of water will abſorb one drachm and a half, or above a 42d part of its weight of nitre; and hence I ſuppoſed the quantity of water which I uſed would have abſorbed above ſixteen times as much, or above three ounces; whereas the event ſhewed that it could not abſorb $\frac{1}{10}$ of an ounce. From the ſinking of the water during the ſolution, I was at

first inclined to believe that some part at least of the nitre was taken into the pores of the water: in order to see whether this conjecture could be verified by fact, I made the following experiment.

EXPERIMENT II.

I chose two matrasses of unequal sizes, containing quantities of water in the proportion of 12 to 1, the diameters of the necks being equal: into the largest I put $\frac{1}{630}$th part of the water's weight of nitre, and an equal quantity into the smaller; and I observed that the water, as well before as after the solution, was equally elevated in them both: this experiment was repeated. Now, if a given quantity of water can absorb into its pores, without being increased in magnitude, any quantity of salt however small, it seems reasonable

sonable to suppose that a quantity containing twelve times as many pores should absorb twelve times as much, (since it is an allowed fact that the minutest portion of a salt is uniformly diffused through the largest quantity of water) and it might consequently be expected, that the water should rise higher in the neck of the smaller matrass than in that of the larger, which is contrary to the experiment.

EXPERIMENT III.

Apprehending that common pump water, with which I had made the preceding experiments, might have its interstices preoccupied by selenites and other heterogeneous matters, and be thereby rendered incapable of admitting into them any additional substance; and observing that Mr. Eller had used in all his expe-

riments 8 ounces of diſtilled water, I had hopes to have reconciled my experiments to his by that means: but upon trial, with diſtilled water, I found the elevation preciſely the ſame as before. Nor do the conclusions depend upon the kind of ſalt; they hold true *mutatis mutandis* of any other ſalt as well as nitre. During the ſolution the water is refrigerated and thereby contracted in magnitude, and the ſmaller the quantity the greater will be the cold and conſequent contraction produced by the addition of ſmall portions of ſalt; but I cannot ſuppoſe that this circumſtance could be overlooked by Mr. Eller, though it induced me to uſe a much larger quantity; or that he attributed the ſinking of the water during the ſolution, to an imbibition of the particles of the

the ſeveral ſalts into the pores of the water, and thence by calculation conſtructed his table.

EXPERIMENT IV.

Having always remarked that the water in the neck of the matraſs was elevated higher upon the firſt immerſion of the ſalt, than after it was wholly diſſolved, I endeavoured to aſcertain the difference in ſeveral kinds of ſalt. To do this with the greater exactneſs, I pitched upon a matraſs which had a neck as far as I wanted it accurately cylindrical as I found by obſerving the elevations occaſioned by the additions of equal portions of water; the matraſs held about 67 ounces of water. The ſalts I uſed were all dry, and in as large pieces as the neck of the mattraſs would admit; the water was heated to the forty-ſecond

degree of Fahrenheit's thermometer, and kept as nearly as could be in that temperature. I changed the water for each experiment, and used in each 24 penny weights of salt; the heights to which the water rose, as measured from a mark in the middle of the tube, before and after the solution of each salt, are expressed in the following table: the first column denotes the height to which the water was elevated by 24 penny weights of salt before its solution, the second after its solution, the third the difference in fractional parts of the elevation before solution.

Elevation by 24 penny weights of simple water	0	58	
24 penny weights of genuine Glauber's salt	42	36	$\frac{1}{7}$
Vol. salt of sal. ammon.	40	33	$\frac{7}{40}$

Sal

Sal ammon.	40	39	$\frac{1}{40}$
Refined white ſugar	39	36	$\frac{1}{13}$
Coarſe brown ſugar	39	36	$\frac{1}{13}$
White ſugar candy	37	36	$\frac{1}{37}$
Glauber's ſalt from Lymington	35	29	$\frac{6}{35}$
Terra foliata tar.	37	30	$\frac{7}{37}$
Rochelle ſalt	33	28	$\frac{5}{33}$
Alum not quite diſſolved	33	28	$\frac{5}{33}$
Borax not half diſſolved in 2 days	33	31	$\frac{2}{33}$
Green vitriol	32	26	$\frac{3}{16}$
White vitriol	30	24	$\frac{1}{5}$
Nitre	30	21	$\frac{3}{10}$
Sal gem. from Norwich	27	17	$\frac{10}{27}$
Blue vitriol	26	20	$\frac{3}{13}$
Pearl aſh	25	10	$\frac{3}{5}$
Vitriolated tartar	22	11	$\frac{1}{2}$
Green vitriol calcined to whiteneſs	22	11	$\frac{1}{2}$
Dry ſalt of tartar	21	13	$\frac{8}{21}$
Baſket ſea ſalt	19	15	$\frac{4}{19}$

Corroſive ſublimate	14	10	$\frac{2}{7}$
Turbith mineral	9	0	

Had I not been in ſome meaſure perſuaded, from the reſult of the preceding experiments, that no portion of any ſalt could be abſorbed into the pores of water, I ſhould have readily concluded that the third column of this table denoted ſuch parts of 24 penny weights of the ſeveral ſalts as might be lodged in the interſtices of 67 ounces of water, without increaſing its magnitude: the quantities indeed which might have been thus aſcertained would have but ill agreed with thoſe which are determined by Mr. Eller; and that diverſity of quantity may ſuggeſt a doubt concerning the validity of his principle. The ſinking of the water in the neck of the matraſs,

ſeems to be a general phænomenon attending the ſolution of all ſalts; the quantity of the deſcent is various from $\frac{1}{45}$ to $\frac{1}{2}$ of the whole elevation in thoſe ſalts which I have tried. In forming the table, I repeated many of the experiments, but found no variation which could affect the general concluſion; with particular attention I repeated the ſolution of vitriolated tartar, for I thought it a very remarkable circumſtance that one of the hardeſt ſalts ſhould be more diminiſhed in proportion to its whole bulk than any other, but the numbers in the table 22 and 11 accurately expreſſed the height before and after ſolution upon the repetition of the experiment, ſo that it may be relied upon as a certain fact that a cubic inch of vitriolated tartar, is by ſolution in water

water reduced to half a cubic inch, though the water cannot, as appeared from an experiment I made, abſorb $\frac{1}{1000}$th part, nor, as I believe, any part, of that ſalt without being augmented in magnitude. It is evident from the table that ſal gemmæ, blue vitriol, corroſive ſublimate, calcined vitriol, and in general thoſe ſalts which retain the leaſt water in their compoſition and conſtitute the hardeſt maſſes, ſink more in proportion to their reſpective bulks than any other. I own myſelf at a loſs for a general principle to explain this general phænomenon, unleſs the air contained in the ſeveral ſalts may be eſteemed ſufficient for the purpoſe; a very copious ſeparation of air from the ſalts during the whole time of their ſolution may be readily obſerved in all of them, and a ſmall

portion

portion of it, combined with the particles of a ſalt, may augment its bulk, without ſenſibly increaſing its weight. Yet the two following experiments rather tend to diminiſh the probability of this opinion.

EXPERIMENT V.

I took water which had been well purged from its air by long boiling, and which had been corked up whilſt it was warm; when it had acquired a proper temperature, I filled a matraſs with it, as before, and putting into it ſal gemmæ, &c. I obſerved that the elevation before ſolution was the ſame as when common water was uſed, and that it ſunk equally in the neck during the ſolution; but then the ſeparation of air ſeemed greatly leſs in all the trials I made. This phænomenon is eaſily explained:

common

common water is always ſaturated with air; upon the addition of any ſalt, the particles of water begin to attract and diſſolve the ſalt, and let go the air with which they are united; this air, added to the air contained in the ſalt, renders the whole much more viſible in common than in boiled water. Muſſchenbroek and others are of opinion, that air only fills the interſtices of water, without augmenting its bulk; they ground their opinion upon obſerving that the ſpecific gravities of common water and of water purged from its air are equal; the fact, taking it for granted, will ſcarcely authorize the concluſion: for, ſuppoſing that a cubic inch of common water contains even a cubic inch of air, the difference of the weight of the water when ſaturated with air, and when freed

freed as much as poffible from it (though probably it can never be wholly freed from it), will not equal $\frac{1}{4}$ of a grain: how imperceptible then muft the difference be, if water, inftead of an equal bulk, doth not contain $\frac{1}{100}$th part of its bulk of air, which is a fuppofition much nearer to the truth: the air is feparated from the water during the folution of the falt, and the particles of the falt probably occupy its place as happens in other chemical precipitations; but we cannot thence infer that they are received into the interftices of the water, unlefs we had more conclufive arguments, to prove that the air itfelf was lodged in them. I varied the preceding experiment by putting two equal and tranfparent pieces of fal gemmæ into two tall drinking glaffes, filled one with common, the other

other with boiled water; from the firſt there continually aſcended a very viſible ſtream of air, and the ſalt and the bottom of the glaſs were covered with bubbles, it ſeeming as if the water quitted its air to diſſolve the ſalt; in the other, though ſome air was ſeen breaking out from the ſalt whilſt it was diſſolving, there did not ſeem to be any precipitated, as it were, from the water. In moſt of the experiments which I made, the boiled water diſſolved a given quantity of ſalt ſooner than the common water, when they had the ſame degree of heat; but the difference in time might be owing to the different magnitude of the ſurfaces of the ſalt, though from the generality of the event, I ſhould rather attribute it to the different diſſolving powers of

water,

water, when replete with, and when deprived of air.

EXPERIMENT VI.

Thinking that the difference in the bulks of the water before and after ſolution might be owing to the ſeparation and eſcape of ſome volatile principle; I took care to balance as accurately as I could, water and ſal gemmæ, water and ſalt of tartar, water and vitriolated tartar, &c. and then putting the ſeveral ſalts into the water, I obſerved when the ſolution was accompliſhed, whether the equilibrium of the ſcales was affected, but I could not diſtinguiſh any change. Dr. Hales and others have ſpoken of the exiſtence of air in ſalts, and have in two or three inſtances inveſtigated the quantity, but after a very different manner

from

from that I have uſed; nor can I think myſelf at liberty to eſteem this air which is ſeparated by ſolution, of the ſame nature with that which is called by him and others fixed air, inaſmuch as fixed air makes a conſiderable part of the weight of the bodies from which it is extracted, precipitates lime water, and is ſeldom diſcharged (or perhaps produced from ſome of the minute parts of the body being converted by the violence of the fire, &c. into an elaſtic fluid), except when the body is decompoſed; whereas this makes only a conſiderable part of the bulk of bodies, and thus diminiſhes their ſpecific gravity without ſenſibly increaſing their abſolute weight; does not, as I collected from ſome rough trials, render lime water turbid; and is ſet at liberty, though not by a

mecha-

mechanical division, yet by an operation somewhat different from chemical decomposition. It hath been remarked by some, that saline solutions will not crystallize without much difficulty in an exhausted receiver; perhaps because the particles of salt cannot attract that principle which should cement them together, which at least may be seen escaping from them when they begin to be separated. Mr. Boyle observed, that aquafortis, poured upon a strong vegetable alkali, did not crystallize till it had been long exposed to the air (though I should rather attribute this failure to the weakness of his aquafortis than to the want of air, since I have frequently, by using the fuming spirit of nitre, obtained crystals of an inch in length almost instantaneously);

 and

and ſeveral other phænomena might be adduced reſpecting the cryſtallization of ſalts, which ſeem to indicate the neceſſity of admitting air as a very efficacious inſtrument in producing that effect: but future experience may tend to elucidate this matter. Having uſed great attention in making the experiments from which the preceding table was compoſed; I thought I had a good opportunity of deriving from it the ſpecific gravities of the ſalts which are there mentioned. I accordingly calculated the following table; in the firſt column of which are expreſſed the ſpecific gravities as calculated from the increaſe of bulk before ſolution; in the ſecond, after the ſolution.

Genuine Glauber's ſalt	1,380	1,611
Cryſtals of kelp	1,414	1,467

Volat. salt of sal ammoniac	1,450	1,787
Sal ammoniac	1,450	1,487
Sugar refined, brown, barley	1,487	1,611
White sugar candy	1,567	1,611
Terra foliata tartari	1,567	1,933
Glauber's salt from Lymington	1,657	2,000
Rochelle salt	1,757	2,071
Alum	1,757	2,071
Borax	1,757	
Green vitriol	1,812	2,230
White vitriol	1,933	2,416
Nitre	1,933	2,766
Very transparent sal gem. from Northwich	2,143	3,411
Blue vitriol purified	2,230	2,900
Pearl ash	2,320	5,800
Vitriolated tartar	2,636	5,272
Green vitriol calcined to whiteness	2,636	5,272

 Dry

Dry ſalt of tartar	2,761	4,461
Baſket ſea ſalt	3,052	3,866
Corroſive ſublimate	4,142	5,800
Mercury diſtilled with acid of vitriol, and freed from its acid by a ſtrong fire	6,444	.

The numbers in the firſt column correſpond very well, upon the whole, with the ſpecific gravities which have been determined by others hydroſtatically; thus the ſpecific gravities of nitre, alum, white and green vitriol, ſal ammoniac, ſal gemmæ, &c. are greater than what are aſſigned to theſe bodies by ſome authors, and leſs than what have been determined by others; it ſeems as if the ſpecific gravities of ſaline bodies might, in a proper veſſel, be more accurately aſcertained from the obſerved

obſerved increaſe of the water's bulk than any other way. Upon the ſuppoſition that the eſcape of the air is the reaſon of the water's ſinking during the ſolution, and that this air contributes little to the weight of the ſalts, though it may be abſolutely neceſſary to the exhibiting the ſaline moleculæ under a viſible cryſtalline appearance; the ſecond column will denote the real ſpecific gravities of the ſalts as freed from air. That this air is combined with the ſalts, and doth not ſimply adhere to their ſurfaces, may appear from hence, that the ſpecific gravities, as calculated from the increaſe of bulk obſerved in the water before ſolution, ſufficiently correſpond with thoſe which philoſophers have determined hydroſtatically: nor indeed, upon exhauſting the air from

the ſalts, by an air pump, could I obſerve that it was ſeparated in leſs quantity during ſolution.

EXPERIMENT VII.

Since equal quantities of ſalt muſt contain equal quantities of air, it might be expected *a priori*, if the eſcape of the air was the occaſion of the water's ſinking, that equal weights of ſalt would produce equal augmentations of bulk, and unequal weights augmentations proportionable to their weights; but, to be aſſured of this, I took a matraſs containing about 30 ounces of water, the tube being cylindrical for about 7 inches in length. When the matraſs was filled to a proper mark, I put into it 7 pennyweights of powdered ſal gem.: the water after the ſolution had riſen through 17 tenths of

of an inch; by the addition of 14 pennyweights more, the water was raiſed through 51 diviſions from the firſt mark, or twice 17 from where it ſtood after the ſolution of 7 pennyweights. In the ſame matraſs I tried a ſimilar experiment with nitre; the water was raiſed through 10 diviſions, by 3 pennyweights of powdered nitre; and by 18 more, it ſtood after the ſolution at the 70th diviſion from the firſt mark, and conſequently roſe through ſix times the ſpace through which it had been raiſed by 3 pennyweights. From theſe, and other experiments of the ſame kind, I am diſpoſed to believe that equal portions of ſalt produce equal augmentations in the bulk of the water wherein they are diſſolved; at leaſt, this holds true when the ſalt diſſolved bears but a ſmall propor-

tion to what would be requisite to saturate the water. But, in making this experiment, great care must be taken to keep the salts of the same dryness; I had once tried it with three equal quantities of sea salt, and arrived at a quite different conclusion; the increases of bulk occasioned by the solution of the several salts being separately taken, as 15, 16, 17, but the salt being much drier than the air in the laboratory, had undoubtedly attracted the humidity, and that portion had attracted the most which had been the longest in it, and which was last dissolved. Nor should the temperature of the water be neglected; a sensible error may proceed from a minute change in that. This experiment confirms the first; for, was any part of salt absorbed into the pores of the water,

it certainly ought to be expected that the elevation occaſioned by the ſolution of 3 pennyweights of nitre ſhould be leſs than $\frac{1}{6}$th of that occaſioned by 18 pennyweights, and yet I found it to be accurately $\frac{1}{6}$th upon repeating the experiment with diſtilled water. It confirms it too in another view, 3 pennyweights or $\frac{1}{200}$th part of the weight of the water, raiſed it through one inch; hence $\frac{1}{2000}$th part would have raiſed it through one tenth of an inch, which any eye may diſtinguiſh.

Dr. Lewis, for whoſe great abilities in chemiſtry I have a very high reſpect, in his little treatiſe upon American potaſhes, is of opinion, that the augmentation of the bulk of water doth not proceed uniformly, according to the quantity of ſalt added; and he forms his concluſion from

from obſerving, that the loſſes of weight ſuſtained by the ſame body in different ſolutions, were not uniform, but continually diminiſhed; the loſſes correſponding to ſeven ſucceſſive equal quantities being as $24\frac{1}{2}$. 24. $23\frac{1}{2}$. 22. 22. 21. 20. Upon conſidering this matter in a mathematical light, I am inclined to draw a quite different concluſion; but I will firſt mention ſome experiments which I had formerly made with a different view, and which agree very well with Dr. Lewis's.

EXPERIMENT VIII.

I had conceived that if, in a given quantity of water, ſeveral quantities of ſalt, increaſing in any arithmetical or geometrical progreſſion, were diſſolved; that the increments of ſpecific gravity would increaſe in the ſame

ſame progreſſion. In order to ſee whether this conjecture could be eſtabliſhed by experiment, I diſſolved in a given quantity of water, different portions of ſea ſalt, increaſing in the progreſſions expreſſed in the annexed tables, where the firſt column of each denotes the proportional quantities of ſalt in pennyweights; the ſecond, the loſs of weight of a given body in quarter grains; the third, the exceſs of the ſpecific gravity of each ſolution, above the ſpecific gravity of water.

Tab. I.

	263	0
9	273	10
18	282	19
27	292	29
36	301	38
45	309	46

Tab. II.

	263	0
5	269	6
10	274	11
15	280	17
20	285	22
25	289	26
30	294	31
35	300	37
40	304	41
45	309	46
50	312	49
55	316	53

Tab. III.

	883	0
4	899	16
8	915	32
12	930	47
16	945	62
20	959	76
24	971	88
28	985	102
32	996	113
36	1009	126
40	1020	137

The difference of the numbers in the third column of each table from arithmetical progreſſions, is obvious at firſt view, the difference of the two laſt numbers of each being conſiderably leſs than the difference between the two firſt: and the numbers 6. 11. 22. 41. correſponding to the geometrical progreſſion 5. 10. 20. 40. in the ſecond table, as well as the numbers 16. 32. 62. 113 correſponding to the geometrical progreſſion 4. 8. 16. 32, in the third, differ conſiderably from geometrical progreſſions, whoſe common ratio is $\frac{1}{2}$.

In making theſe experiments there are three obvious ſources of error: the heat may not remain conſtant; the additional weights of ſalt may not be accurately equal; and the weight of the given body may be

more

more or lefs than what is expreffed by any quantity lefs than $\frac{1}{4}$ of a grain; yet the differences of the preceding numbers, from arithmetical or geometrical progreffions, are too great to be explained from any or all of thefe fources taken together. We may obferve that the loffes of weight, correfponding to equal portions of falt, are, upon the whole, diminifhed; but it will not follow from thence that the bulks are not equally augmented. For, fince the fpecific gravity of every body is properly denoted by a fraction, whofe numerator expreffes the abfolute weight, and denominator the magnitude of the body; let $\frac{w}{m}$, $\frac{w+x}{m+y}$, $\frac{w+2x}{m+z}$, $\frac{w+3x}{m+s}$, &c. be a feries of fractions, whofe feveral numerators exprefs the weights of a

given quantity of water, as increaſed by the addition of equal portions of any ſalt denoted by x, and whoſe denominators expreſs the bulks of the water after the ſolution of each portion of ſalt, the increments of bulk being denoted by y, z, s; now let us ſuppoſe that the loſſes of weight ſuſtained by the ſame body, that is, the ſpecific gravities, increaſe uniformly, then will the above ſeries of fractions increaſe uniformly, let $\frac{w}{m}=a$; $\frac{w+x}{m+y}=a+b$; $\frac{w+2x}{m+z}=a+2b$; $\frac{w+3x}{m+s}=a+3b$, from theſe equations inveſtigating the proportion between y, z, s, which repreſent the augmentations of bulk, it will appear that $y : z : : a+2b : 2a+2b$, or in a greater ratio than that of $1 : 2$, and that $z : s : : 2a+6b : 3a+6b$, or in a greater ratio than that of $2 : 3$, in

 which

which ratios they ought respectively to have been, had the denominators or the bulks of the fluid increased uniformly, when the specific gravities or absolute weights increased uniformly. We see from this, what conclusion should have been formed, had the increments of specific gravity from equal portions of salt been equal. Again, suppose that $\frac{w}{m}, \frac{w+p}{m+q}, \frac{w+2p}{m+2q}, \frac{w+3p}{m+3q}$, &c. denote a series of fractions, whose numerators, expressing the weights of a given quantity of water as increased by the addition of salt, and whose denominators, expressing the bulks, both increase uniformly, then will the several differences between the 2d and 1st, between the 3d and 2d, and so on, be as $\frac{1}{m \times \overline{m+q}}, \frac{1}{\overline{m+q} \times \overline{m+2q}}, \frac{1}{\overline{m+2q} \times \overline{m+3q}}, \frac{1}{\overline{m+3q} \times \overline{m+4q}}$, &c. which fractions

fractions being inversely as their denominators, constitute a decreasing series; but the increments of specific gravity, from the addition of equal portions of salt, are proportionable to these fractions, and therefore ought perpetually to decrease, though we allowed the bulk of the compound to be precisely equal to the bulk of the water and salt taken together, that is, though we allowed the bulk of the water to increase uniformly according to the quantity of salt added: now as it is evident from Dr. Lewis's experiments, and from each of the preceding tables, that the increments of specific gravity do decrease upon the whole, when the absolute weights increase uniformly, we may venture to conclude that the bulks increase uniformly also. I thought proper

to explain the foregoing principle, and to determine the ratio, becauſe the matter ſeems to have been miſtaken by many; however, it may be eaſily apprehended that the increments of ſpecific gravity, from the addition of equal quantities of ſalt to a given weight of water, ought perpetually to decreaſe: becauſe the difference between the ſpecific gravities of the water and of the ſalt perpetually decreaſes, as the water approaches to perfect ſaturation. In like manner, if to a given quantity of water we add any number of equal quantities of oil of vitriol, or any fluid miſcible with and heavier than water; the increments of ſpecific gravity will perpetually decreaſe, though they will never entirely vaniſh, becauſe there is a perpetual approximation to the ſpecific

gravity of the acid, which yet the mixture can never acquire; and, *vice versa*, if to water we add a lighter fluid, as spirits of wine, by equal portions, the specific gravity of the mixture will constantly decrease by unequal decrements; but the decrements will never vanish, because the mixture must ever remain specifically heavier than spirit of wine.

EXPERIMENT IX.

The quantities of various salts, which may be dissolved in a given quantity of water, have been ascertained by Boerhaave, Eller, Spielman, and others; their accounts differ somewhat from one another, as might be expected from the different temperatures of the air, the different state of their salts, the dif-

ferent times (a circumſtance of no ſmall conſideration in this matter) which they allowed the water to act upon the ſalts before they concluded it to be fully ſaturated, and from ſome other circumſtances which might perhaps with advantage be taken into the account, and a more accurate table compoſed than hath hitherto been publiſhed; but as the differences would be ſmall, and might not tend to any new diſcoveries, I could not perſuade myſelf to be at the trouble of making the requiſite experiments. I thought it would be a more uſeful undertaking to determine the ſpecific gravities of ſaturated ſolutions of various ſalts. In compoſing the following table, I uſed every poſſible precaution; the ſolutions were fully ſaturated, by permitting the water to

reſt upon the ſalts for ſome weeks, and frequently ſhaking the ſolutions during the interval: I had ſome reaſons for chooſing this method rather than the much ſhorter one of diſſolving the ſalts in hot water, and letting the ſolutions cool, though the event will be much the ſame in both ways; my balance was extremely ſenſible, though I did not uſe any weight leſs than a quarter of a grain; the water in which the ſalts were diſſolved was not $\frac{1}{4}$ of a grain in 890 heavier than diſtilled water; the ſolutions were all of the ſame temperature, Fahrenheit's thermometer ſtanding between 41 and 42° during the whole time of taking the ſpecific gravities.

A Table exhibiting the ſpecific gravities of water ſaturated with various

various falts. Thermometer 41—42°, barometer 30 inches.

Water in which the falts were diffolved	1,000
Saturated with quicklime	1,001
Cryftals of tar	1,001
Arfenic	1,005
Borax	1,010
Corrof. fublim.	1,037
Alum	1,033
Genuine Glauber's falt	1,052
Vitriolated tart.	1,054
Common falt	1,198
Arfen. nitre	1,184
Glau. falt Lyming.	1,232
Sal ammon.	1,072
Vol. falt of fal am.	1,077
Cryftals of kelp	1,087
Nitre purified	1,095
Rochelle falt	1,114
Blue vitriol	1,150

Green vitriol	1,157
Sal gemmæ	1,170
Epſom ſalt Lym.	1,218
White vitriol	1,386
Pearl aſh	1,534

By making other tables ſimilar to the preceding, when the thermometer ſtands at 62°, 82°, 102°, &c. or when the heat increaſes or decreaſes in any known ratio; it is extremely probable that the law, according to which the diſſolving power of water varies with the variation of its heat, might be inveſtigated. I have ſome reaſons for thinking that though it increaſes with the increaſe of heat, yet it doth not increaſe in the direct ſimple ratio of the heat; but what the law is, or whether all ſalts follow the ſame law, I cannot, from any experiments I have already made,

made, determine; and I have no leiſure at preſent to proſecute the inquiry. The concluſion will be unavoidably liable to a ſmall inaccuracy; for whether the ſpecific gravities be inveſtigated by weighing the ſeveral fluids in a given veſſel filled to a given mark, or by weighing a given ſolid in each of them, we ſhall not thence obtain the weights of equal bulks, ſince the containing veſſel or the ſolid, from the difference of the heats, have a different capacity or a different bulk. However, it is not apprehended that this circumſtance would ſenſibly affect the concluſion, eſpecially as it is ſubject to calculation and might be allowed for. It ought, at the ſame time, to be obſerved, that a given bulk of the water with which the ſpecific gravities are compoſed,

will have different weights when the heats are different; and these differences ought first to be ascertained.

EXPERIMENT X.

Having thus determined the specific gravities of saturated solutions of several salts, in a given degree of heat; my next inquiry was to find the specific gravities of water impregnated with a given quantity of the several salts: I accordingly dissolved in 168 pennyweights of water, 14 pennyweights, or $\frac{1}{12}$ of the weight of the water of the eight following salts. The thermometer was at 40°, and barometer at $29\frac{1}{2}$.

A Table of the specific gravities of water impregnated with $\frac{1}{12}$ of its weight of

Water	
Sea salt	1,059

Blue

Blue vitriol	1,052
Nitre	1,050
White vitriol	1,045
Green vitriol	1,043
Glau. falts Lym.	1,039
Glau. falts Genu.	1,029
Sal ammon.	1,026

I could not have made this table much more extenfive, fince in the 40th degree of the thermom. water will not diffolve $\frac{1}{12}$ of its weight of alum, borax, vitriolated tartar, corrofive fublimate, and a great many other falts; however, as fuch a table cannot fail of being ufeful in chemical, and perhaps medical refearches, it would be worth while to make it more general, either by diffolving a lefs portion of falt, or making ufe of a greater degree of heat.

EXPE-

EXPERIMENT XI.

To theſe tables I have ſubjoined another of a different nature, wherein the ſpecific gravities of water impregnated with different quantities of the ſame ſalt from $\frac{1}{3}$ down to the 1024th part of the weight of the water, are determined. I cannot accuſe myſelf of careleſſneſs in making any of the experiments from which the table is formed; but part of it being made in a room where the heat was about 55°, and the other in my laboratory, when it did not exceed 46°, a certain inaccuracy, though it will be a very ſmall one, and ſcarce ſenſible in the weight of the ſmall body which I uſed, will attend it upon that account. The ſalt was ſea ſalt of the fineſt kind,

and

and extremely dry; many of the experiments were repeated.

A Table of the ſpecific gravity of water impregnated with different quantities of ſea ſalt. Thermometer between 46 and 55°.

Water	1,000
Salt $\frac{1}{3}$	1,206
$\frac{1}{4}$	1,160
$\frac{1}{5}$	1,121
$\frac{1}{6}$	1,107
$\frac{1}{7}$	1,096
$\frac{1}{8}$	1,087
$\frac{1}{9}$	1,074
$\frac{1}{12}$	1,059
$\frac{1}{14}$	1,050
$\frac{1}{15}$	1,048
$\frac{1}{16}$	1,045
$\frac{1}{18}$	1,040
$\frac{1}{21}$	1,032
$\frac{1}{24}$	1,029

$\frac{1}{27}$

$\frac{1}{28}$	1,027
$\frac{1}{32}$	1,025
$\frac{1}{30}$	1,024
$\frac{1}{32}$	1,023
$\frac{1}{36}$	1,020
$\frac{1}{39}$	1,019
$\frac{1}{45}$	1,015
$\frac{1}{43}$	1,014
$\frac{1}{54}$	1,013
$\frac{1}{55}$	1,012
$\frac{1}{72}$	1,009
$\frac{1}{84}$	1,007
$\frac{1}{108}$	1,006
$\frac{1}{126}$	1,005
$\frac{1}{144}$	1,004
$\frac{1}{160}$	1,003
$\frac{1}{[illegible]}$	1,0029
$\frac{1}{[illegible]}$	1,0023
$\frac{1}{320}$	1,0018
$\frac{1}{[illegible]}$	1,0017
$\frac{1}{512}$	1,0014

$\frac{1}{848}$	1,0008
$\frac{1}{1028}$	1,0006

From this table it will be eaſy to determine how much the ſpecific gravity of water is increaſed by the ſolution of a given quantity of ſalt, and, *vice verſa*, if we know the ſpecific gravity of any ſolution of ſalt, we may form a good conjecture of the quantity of ſalt contained in it, which obſervation may be of ready uſe in eſtimating the ſtrength of brine ſprings, and of ſea water, taken up in different climates, or upon different coaſts in the ſame climate. Thus, if a ſalt ſpring, or ſea water, ſhould weigh $\frac{1}{50}$ more, bulk for bulk, than common water; we may conclude that it contains $\frac{1}{36}$ of its weight of ſalt; if $\frac{1}{40}$, it hath nearly $\frac{1}{28}$; if $\frac{1}{25}$, $\frac{1}{18}$; if $\frac{1}{20}$, $\frac{1}{14}$; and ſo on: we may always find limits

limits near enough to form a conclusion from, though the exact number denoting the weight in any particular case should not be met with in the table.

After I had drawn up the preceding account of the experiments which I had made, I received the Berlin Memoirs for 1762, published last year, in which there is a memoire entitled—*Experiences sur le poids du sel & la gravité spécifique des saumures, faites & analysées par M. Lambert.* In this memoire, the very ingenious author hath made much use of the principle, which I have endeavoured to call in question in the beginning of this paper; and hath calculated the different quantities of sea salt, which are absorbed into the pores of water, when a given quantity is dissolved in different

ferent quantities of water. The admission of this principle hath drawn him into some conclusions which seem not quite consonant to true philosophy; as when he asserts that the quantity which is absorbed into the pores, is not proportional to the number of the pores or the quantity of water: for, if a given quantity of water, suppose *A*, will absorb a given quantity of any salt, suppose *a*, I can see no possible reason why *m A* should not absorb *m a*: for imagining *m A* to be divided into portions respectively equal to *A*, and equal quantities of salt to be dissolved in each of them; then, from the supposition, each of them will absorb *a*; and when they are all mixed together, as no precipitation will ensue, the sum, or *m A*, must have absorbed *m a*. But I have no

inclina-

inclination to animadvert upon what ſeems to be a ſmall miſtake of an author, whoſe various writings do much honour to philoſophy in general, nor to involve myſelf in a diſpute with any one. The following experiment may perhaps be thought concluſive againſt the doctrine of ſalts being abſorbed into the pores of water: I took a large glaſs receiver, containing near ſix gallons; into its neck, by means of a hole bored through a cork, I cemented a ſmall glaſs tube; and having filled the whole up to the middle of the tube with water, I dropped in a piece of ſea ſalt, weighing leſs than one forty thouſandth part the weight of the water: the water inſtantly roſe in the tube, continued ſinking during the ſolution, but at laſt remained as much elevated as it

would have been had there been no more water than what would have been ſufficient to diſſolve it. In making this experiment, the receiver ſhould not be touched by the hand; for its parts ſuddenly expanding themſelves occaſion an inſtantaneous ſinking of the water in the tube, as I have frequently experienced, and might thus induce a ſuſpicion of the water's not being elevated by the addition of ſalt. I would not be underſtood from theſe experiments to deny the poroſity of water, ſince philoſophers have thought that the paſſage of light through it, and other phænomena, indicate the exiſtence of vacuities in it; but I cannot believe, however ſolution be carried on, that the ſmalleſt quantity of ſalt can be diſſolved in the largeſt quantity of water, without increaſing its magni-

 tude

tude. The cauſe of the water's ſinking during ſolution doth not appear to be ſo certain; the eſcape of air, to which all the appearances induced me to refer it, and to which it may perhaps ſtill be owing, ſeems to be liable to ſome objections, not only from the experiments I have before mentioned, but from the following.

EXPERIMENT XII.

I took two matraſſes of equal dimenſions, one filled with common water, the other with boiled water. I poured into them equal quantities of oil of vitriol; in the firſt there ſeemed to be an univerſal precipitation of air, as it were, from every particle of the fluid, which, by little and little, formed itſelf into larger bubbles, and, aſcending through the neck, eſcaped; in the other, hardly any

any air could be obſerved, the water ſunk during the ſolution of the acid very apparently, yet $\frac{1}{1000}$th part of the water's weight of acid cauſed a ſenſible elevation: ſo that, whatever may be thought of the cauſe of the water's ſinking during the ſolution of a ſalt, the principle of its being to a certain degree imbibed into the pores of water ſeems in no caſe to be true, whether the ſalt be in a concrete or fluid form. This ſubject may receive ſome illuſtration from what is obſerved in the freezing of water; ice from common water is always ſpecifically lighter than water, from its retaining in its concrete form ſeveral air-bubbles, which enlarge its bulk without adding to its weight; this ice, when put into a matraſs, after the manner in which all the preceding ex-

 periments

periments with ſalts were made, would elevate the water moſt upon the firſt immerſion : the water would ſink as the ice melted ; equal portions of ice would produce equal elevations both before and after ſolution ; the air would be ſeparated in a form more or leſs viſible, according to the circumſtances in which the experiment ſhould be tried ; and not the ſmalleſt portion of ice could be diſſolved without increaſing the bulk of the whole. Salts do not ſeem to differ much from ice in the manner of their formation ; and as ſimilar phænomena attend their ſolution in water, why may we not explain them from the ſame cauſe ? But if any one ſhould think differently, notwithſtanding the experiments which have been produced, I profeſs myſelf

ſelf extremely ready to liſten to any reaſoning founded upon experiment which may tend to prove my opinion to be erroneous; having no partiality for any thing but truth, nor being aſhamed of ignorance or miſtake in any matter, reſpecting the comprehenſion or explication of even the minuteſt operation of nature: *ego quidem hoc ſum contentus, quod licet quo quidque fiat ignorem, quid fiat intelligo.*

[This Eſſay has had a flattering attention paid it by foreigners; I know it has been tranſlated into the French, and I believe it has been tranſlated into the German language.]

THE following Eſſay was written near twenty years ago; a few copies of it were printed, but not publiſhed, in 1771: it was animadverted on by the late Doctor Hawkeſworth in the Gentleman's Magazine, by the authors of the Journal Encyclopedique, and in ſome other periodical publications about that time. There is a ſpeculation advanced in it relative to the perceptivity of vegetables, which I would not be thought to maintain

with any pertinacity, yet I am pleafed to fee that fo able a writer as Dr. *Percival* has fupported the fame fide of the queftion *. Whether vegetables have or have not the faculty of perception, is one of the many queftions which it is pleafant to difcufs, but difficult to decide; the arguments in favour of the affirmative fide are fuch as rather invite affent than extort conviction.

The opinion which I have endeavoured to illuftrate, has not, I find, that novelty to recommend or to difgrace it, which, when I wrote the Effay, I thought belonged to it; it has been incidentally adopted by ancient and modern authorities of great weight: I will quote the words of four diftinguifhed authors to this purpofe.

* Manchefter Mem. Vol. II. p. 114.

Stobæus

Stobæus acquaints us, that *Plato* thought plants were living bodies, endued with ſenſation. His words are —Πλατων και τα φυτα εμψυχα ζωα. φανερον και απο του σαλευεσθαι, και εντεταμενους εχειν τους κλαδους, και ταις επαγωγαις εικειν, και παλιν σφοδρως αναχαλασθαι και αισθητικα, ενια δε και λογικα *. — *Cardanus* expreſſes himſelf in the following terms: *Nobiliores metallicis plantæ ſunt, atque in his quædam ſenſus imago relucet. Etenim et odiſſe et amare plantas, et membra habere functionibus opportuna, ſatis clarum eſſe puto* †.—*Rurſus quæritur, quare in mari quædam plantæ ſentiant, in terra non? At hoc inferius exponetur. Igitur forſan in craſſo aëre aliquam plantam, quæ ſenſum habeat, et ſimilem carni imperfectæ,*

* Stob. Ecl. Phyſ. L. i. p. 87.

† Cardan. de Subtil. L. iii. de Plantis.

qualis

qualis eſt cochlearum et piſcium, non erit impoſſibile *.

The words of *Ray* are very remarkable—*Facultas ſentiendi animalibus tam propria cenſeri ſolet, ut eorundem differentia eſſentialis a philoſophis conſtituatur. Verum plantæ nonnullæ* Æſchynomenæ *veteribus dictæ, recentioribus* vivæ, *et* ſenſitivæ, *et* minoſæ, *haud obſcura ſenſus indicia produnt.* He then mentions the moſt remarkable motions obſervable in ſenſitive plants, and aſks, *Quomodo hæc fiant, ſi ſenſum omnem et motum* ſpontaneum *iis denegemus mechanica aliqua ratione explicare perdifficile eſt* †?

Laſtly, the animal nature of vegetables is acknowledged as probable by *Spallanzani*, who is juſtly eſteemed the greateſt naturaliſt of the

* Id. de Rer. vari. L. vi. c. 22.

† Ray. Hiſt. Plan. Tom. I. l. 18.

the preſent age. Having remarked that *Haller* was the firſt who ſhewed that in birds the fœtus exiſts before fœcundation, and that he himſelf extended the diſcovery to different ſpecies of amphibious animals, and to ſome ſorts of plants, he adds, "Hence we have a new and ſtriking point of analogy between plants and animals to be added to the many others long known; and hence the ſuſpicion that theſe two tribes of organized bodies compoſe, perhaps, but one immenſe family, receives ſtrong confirmation *."

It would be diſingenuous to conceal the ſentiments of thoſe who think that perception does not in

* Diſſert. on the Nat. Hiſt. of Anim. and Veget. by Abbé Spallanzani. Engl. Tranſ. Vol. II. p. 315.

any

any degree belong to plants; I will lay before the reader ſome authorities on this ſide of the queſtion, that the weight of the argument, *ad verecundiam*, may be equal on both ſides.

Sir John Hill, in his Vegetable Syſtem, places the difference between vegetables and animals in a ſyſtem of nerves which belongs to animals, but not to vegetables: "Vegetables," ſays he, "are placed by nature in a middle ſtate, between the mineral and the animal claſſes: ſuperior to the mineral in having organized bodies, inferior to the animal kinds in wanting a nervous ſyſtem. They are capable of growth, but below ſenſation *.

M. *Gleditſch* ſays—*Les plantes appartiennent à la claſſe des corps vivans*

* Hill's Veg. Syſ. B. II. p. 1.

dans

dans la nature. Elles ont leur ſtructure exactement regulière, tout comme les animaux, avec leſquels elles ont beaucoup de reſſemblance par rapport à leur génération. Une des principales propriétés, celle que nous nommons l'irritabilité, leur eſt pareillement commune; mais pour l'autre, ſavoir la ſenſibilité, elle demeurera toujours propre aux animaux *.

The opinion of *Haller* is thus expreſſed—By irritability, M. de *Haller* means, that property which certain parts of living bodies poſſeſs, of contracting when wounded, or even when touched, independent of the will of the animal that is ſubject to the experiment, and without its feeling any pain; a property which plants ſeem alſo to partake, and

* L'Acad. des Scien. Berlin, 1765. p. 52.

which,

which, being diſtinct from ſenſibility, does not depend on the ſame organs. He endeavours to prove, that irritability reſides excluſively in the muſcular fibres, and ſenſibility in the nerves *.

* Memoirs of Haller, by Tho. Henry, p. 72.

ESSAY III.

On the Subjects of Chemiſtry, and their general Diviſion.

ALL terreſtrial exiſtencies may, in one view or other, be conſidered as the ſubjects of Chemiſtry: they are uſually divided into three diſtinct claſſes, called the three kingdoms of nature; the firſt includes Minerals, the ſecond Vegetables, the third Animals. Natural hiſtory, in an extended ſenſe, comprehends the knowledge of whatever relates to terreſtrial exiſtencies, excluſive of the moral actions of man, which conſtitute the baſis of civil hiſtory; and of the phyſical actions of bodies one

upon another, which are the foundation of natural philoſophy.

Mineralogy is that part of natural hiſtory which treats of whatever is found upon the ſurface, or dug out of the bowels of the earth; except animal and vegetable ſubſtances: ſome have excepted water alſo, and denominated that branch of ſcience which explains the properties of water, Hydrology. And, indeed, many chemiſts have thought proper to conſider water, as not appertaining to any of the three kingdoms of nature; but it hath no better right to be diſtinguiſhed from a ſolid, elaſtic, diaphanous mineral, than a melted metal hath to be diſtinguiſhed from the ſame metal when concreted into a ſolid form: in their different ſtates of fluidity and ſolidity they will have different proper-

tirs; but should not, from such accidental changes as are effected by minute variations of heat, be referred to different classes: had water been called melted ice, no one would have scrupled to consider it as belonging to the mineral kingdom.

The reducing quicksilver into a solid, malleable metal, by a due degree of cold, was an important discovery in physics: we learn from thence to consider all fluid bodies, such as water, oils, spirits, æthers, and probably the air itself, as convertible into solids without the introduction of any frigorific particles, but simply by a diminution of heat; and all solid bodies, as convertible into fluids, without suffering any other change in their constitution, except what arises from the volatilization of such of their prin-

ciples, as cannot ſuſtain the degree of heat requiſite to render the reſt fluid.

Mineralogy is principally employed in arranging ſimilar bodies under the ſame, and diſſimilar bodies under different denominations. It judges of ſimilarity two ways; either from the ſimilarity of the external appearance, or from the ſimilarity of the internal conſtitution. The knowledge of the ſimilarity of the internal conſtitution of bodies is acquired, chiefly by regarding the changes produced in them by the action of fire, or the action of menſtruums; that of the external appearance by regarding the colour, configuration of the ſuperficial parts, conſiſtency, and weight. From the knowledge of the conſtituent parts of bodies is derived their œconomical

mical application, their uſe in medicine, agriculture, metallurgy, and other arts: from the ſimilarity of the external appearance, is derived a ſuſpicion concerning the identity of the internal conſtitution; a ſuſpicion, ſerviceable in ſuggeſting conjectures to philoſophic minds, relative to the generation, tranſmutation, and deſtruction of natural bodies.

Moſt mineraliſts have contented themſelves with claſſing the various ſpecies of foſſils according to their moſt obvious qualities, and have thereby referred things very heterogeneous to the ſame genus. In the animal and vegetable kingdoms, the external appearance is of eſſential uſe in helping us to reduce them into genera and ſpecies: indeed, when from a reſemblance in one or

two particular parts of a plant or an animal; as from the figure of the leaves, or the number of ſtamina; from the ſhape of the hoof, or the number of teeth, we venture to arrange them under the ſame general denomination, great confuſion will ariſe, if we ſuppoſe that general denomination to infer a reſemblance more extenſive than the idea from whence it was derived; nature often admitting a ſimilarity in ſome particulars, coexiſtent with the greateſt diſſimilarity in others: it is not probable, however, that *Linnæus* in claſſing the productions of nature ever entertained ſuch a ſuppoſition, and he ſeems therefore to have been uncandidly cenſured. But when the whole external appearance of a plant, or an animal, is taken into conſideration, it is far eaſier to refer

fer it to a particular claſs, than from a chemical enquiry into its internal conſtitution. In fact, the internal conſtitution depends, in a great meaſure, upon the ſame principle from which the external figure is formed. From the configuration of the vaſcular ſyſtem, through which nutrition is conveyed to every part of a plant or an animal, is derived the external figure; and from the ſame configuration the internal properties ſeem to ariſe: for plants become aceſcent or alcaleſcent, ſweet or bitter, poiſonous or ſalubrious, according to their different natures, though they be planted in the ſame ſoil, and fed with the ſame food, that being changed and elaborated, by proceſſes which we can neither underſtand nor imitate, into different fluids by the different organizations, and, I

had almoſt ſaid, digeſtive powers of different plants. The caſe is quite otherwiſe with reſpect to minerals, the external appearances conveying to us little real knowledge; they may be the ſame in different bodies, or different in the ſame body.

Sir Iſaac Newton has proved, that the colours of natural bodies depend upon the thickneſs and denſity of the component parts, and conſequently that minute changes in either of theſe qualities will make very conſiderable changes in the colour: this philoſophy is confirmed by, and ſerves at the ſame time to explain, many appearances in chemiſtry. Cryſtals of quickſilver in *aqua fortis*, are white, yellow, or red, according to the degree of heat to which they have been expoſed; whilſt on the other hand, the ſame

quick-

quickſilver corroded into a ſaline maſs by oil of vitriol, remains perfectly white in all degrees of heat, but by the affuſion of water is changed at once into a vivid yellow, which is of different ſhades according as the water is hot or cold, or as the maſs hath been more or leſs freed from its adhering acid by calcination. Iron and lead, and moſt other metals, undergo ſimilar changes of colour from calcination and precipitation, ſo that nothing ſeems more uncertain than the claſſing of bodies from a reſpect to their colour. This uncertainty of colour, according as the heat is various, is much felt and complained of by enamellers, and the makers of artificial gems.

The configuration alſo of the ſuperficial parts is a very uncertain

characteristic of the specific nature of a mineral; metallurgists are sensible of this; they are obliged in many cases to have recourse to fire, before they can pronounce concerning the metal contained in an ore, whether it be lead or silver, iron or antimony. We have a notable instance of this uncertainty in what is called the stellated regulus of antimony; the crystallization on the surface resembling the radiations of a star, the scales of a fish, branches of trees, fibrillæ of feathers, and other matters, according to certain diversities of circumstances attending the process. I do not deny but that a definite degree of liquidity in the *regulus* and *scoria*, a definite quantity and quality of the *scoria*, and a proper precision in some other matters, would ever produce a definite arrangement of the superficial

parts; but it is certain that a ſmall variation in any of theſe will make a great change in the outward and inward appearance of the regulus, without affecting in any ſenſible manner its internal compoſition. Another inſtance will ſhew the imperfection of this external method of claſſification ſtill more obviouſly: in ſeveral portions of water let there be diſſolved nitre, ſea ſalt, alum, borax, ſugar, ſaccharum ſaturni, corroſive ſublimate, &c. or any combinations of theſe ſalts, the ſeveral ſolutions will ſtill be equally colourleſs and tranſparent, and by a ſufficient degree of cold ſuddenly applied would be concreted into ſolid bodies, not to be diſtinguiſhed from one another by their colours, figures, conſiſtencies, nor (ſo the experiment might be managed) ſpecific gravities.

By these instances from chemistry, we can apprehend how there may be a perfect similarity in the external appearances of bodies, when their internal constitutions are wholly different, and a dissimilarity, when they are wholly the same. The minerals produced by nature are analogous to those of art, and hence we may infer the great confusion and obscurity which must necessarily attend a natural History of Minerals, when it is founded only on the external appearance.

Sensible at last of this imperfection, the composers of systems of mineralogy have availed themselves of the assistance of chemistry, and have endeavoured to class minerals according to their internal properties. This method is perfect in its kind; and in particular instances deserves

deferves greater or lefs attention, according as the analyfis of minerals is more or lefs complete: in many cafes however it is too general and abftracted for common ufe. For inftance, all earths or ftones which by a certain affignable degree of heat, and with a certain quantity of faline additions, are convertible into glafs, may be called vitrifiable earths; all earths or ftones which in the fame degree of heat, and with the fame quantity of faline additions, or without them, are not convertible into glafs, but into quicklime, may be called calcareous earths; and all earths or ftones which under fimilar circumftances remain unaltered in their properties, may, with refpect to the other two kinds, be called refractory earths. This is all we can learn from chemiftry

miſtry relative to the comparative natures of earths, when expoſed to a given degree of heat; and hence fiſh-ſhells, chalk, limeſtones, and marbles would be included in the ſame claſs: but to anſwer the purpoſes of common life, it will be neceſſary to make a more particular diviſion of them, which can only be done after the generic idea hath been eſtabliſhed, by contemplating the external appearances; in which view the colour or figure, or both together, would be principally reſpected; as in fact we ſee they are in the diſtinction of the Italian *Antico's*, as *Marmore Nero*, *Giallo*, *Roſſo di ſan giuſto*; *di Fiorenza*, *Paeſino*; *Alberino di Monte Gallicano*, &c. all of which are convertible into quicklime, but from their different colours, ſuperficial contextures, and capabi-

lities

lities of receiving different polishes, they have become of different values in a commercial light, and therefore are not improperly distinguished in a system of mineralogy. In like manner, though a chemical examination by fire would probably refer diamonds, emeralds, rubies, topazes, and other stones generally denominated precious, to the class of flints; yet since men have annexed a fanciful value to these pebbles from their pellucidity, colour, hardness, and other external attributes, it would be a great defect in a mineral system not to have them particularly specified and described.

But to discriminate common limestones, or common flints into different species, from a minute variation of the figure or the colour; to class pyrites, or combinations of sulphur

and

and iron, under the ſpecific denominations of ſpherical, hemiſpherical, pyramidal, cubical, &c.; to divide, as is uſually done, the ores of the ſame metallic ſubſtance into a great variety of kinds, when an aſſay will give no difference either in the quantity or quality of the metal contained in them, or of the matter by which they are mineraliſed, ſeems to be a multiplicatio entium præter neceſſitatem, and tends rather to obſcure and circumſcribe, than to elucidate and extend our knowledge of nature.

Upon the whole, the great outlines and general diviſions of mineral productions may moſt uſefully be made from a chemical inveſtigation of their conſtituent parts, and where it is expedient for commercial purpoſes to be more particular, an

an attention to the external appearance will be proper for that end. A mineralist who considers gypseous alabasters, plaster stone, lamellated gypsums, rhomboidal selenites, *spatum Bononiense*, and a great many other bodies as proper to be distinguished from one another, and who is able to ascribe any particular body to its proper species from considering its external appearance, is possessed of a particular kind and degree of knowledge: He who, besides being acquainted with the external appearances, is able to prove that all these different bodies are composed of a calcareous earth, united to the vitriolic acid; and thus make several species of things coalesce together, and unite, as it were, under one general conception, hath a knowledge of these bodies

different in kind, and superior in degree. By this sort of knowledge the memory is much relieved, and the mind, ever grasping after universal truths, is gratified with the acquisition of general ideas. These two very different kinds of knowledge belong to every part of mineralogy; in different views each of them is of indispensable use, and a perfect system of mineralogy should include them both.

If it be asked what are the discriminative characteristics of minerals, vegetables, and animals, as opposed to one another, I plainly answer that I do not know any, either from natural history or chemistry, which can wholly be relied on.

Systematic distinctions, and specific divisions of things, are useful in enlarging the comprehension of the

mind; by methodizing the objects they ſeem to extend the boundaries of knowledge: but having no real foundation in nature, they ſhould not be depended on too far; they often perplex or impede the progreſs of a curious inquirer. This prepoſſeſſion in favour of ſyſtematic arrangements, operates more forcibly upon us as the ideas to which it is uſually annexed become the more abſtracted. The ſtrongeſt analogies are overlooked, the plaineſt reaſonings thought fallacious, and deciſive experiments inconcluſive, when their tendency is to ſubvert a diſtinction, of which we had wrongly ſuppoſed Nature herſelf the author. Every one thinks that he knows what an animal is, and how it is contradiſtinguiſhed from a vegetable; and would be offended at having his knowledge que-

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ſtioned thereupon. A dog or a horſe, he is truly perſuaded, are beings as clearly diſtinguiſhed from an herb or a tree, as light is from darkneſs; yet as in theſe, ſo in the productions of nature, the tranſition from one to the other is effected by imperceptible gradations.

The loco-motive powers which appertain to moſt animals, whether they proceed from the *Carteſian* mechaniſm, or from ſenſation, are ſo manifeſt in quadrupeds, birds, fiſhes, and inſects, that in our firſt and ſuperficial inquiries into nature, we are apt to conſider the poſſeſſion or want of theſe powers, as making a deciſive and eſſential difference between animal and vegetable bodies; and it is not without a certain degree of regret, as it were, that we find ourſelves obliged to predicate ani-

animality concerning a great variety of beings, which are destitute of every power of progressive motion. If at the same time we happen to have entertained some preconceived opinions, no matter whence they have been derived, concerning the usual shapes of animals, (though they are far more different from one another than some of them are from vegetables), our repugnancy to the admitting a being of the outward form of a shrub, into the class of animals, is much increased. Hence have proceeded most of the objections which have been made to the fine discoveries of *Peyssonel*, *Jussieu*, *Ellis*, and others, relative to the animal nature of corals, madrepores, millepores, corallines, spunges, and a numerous tribe of bodies which

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the very ingenious labours of *Marsigli* had formerly removed from the mineral kingdom, where they had been placed by *Woodward* and other Mineralifts, and allotted to that of vegetables.

If, rejecting fpontaneous motion and figure as very inadequate tefts of animality, we adopt perception in their ftead; no doubt, he would be efteemed a vifionary in Philofophy who fhould extend that faculty to vegetables; and yet there are feveral chemical, phyfical, and metaphyfical reafons which feem to render the fuppofition not altogether indefenfible.

The greater the quantity of perception exifting in the univerfal fyftem of creation, the greater is the quantity of happinefs produced; and the greater the quantity of happinefs pro-

produced, the greater is the goodneſs of the Deity in the eſtimation of beings with our capacities. The latter part of this propoſition needs no proof; and the former is liable but to one objection, and that grounded upon a falſe ſuppoſition. If, it may be urged, all the ſpecies of percipient beings be not accommodated with objects congruous to their faculties of perception, and productive of more pleaſure than pain to the whole ſpecies taken collectively, then the animation of that matter of which they conſiſt is an introduction of evil, and no teſt of benevolence. This may be granted; but in all the ſpecies of beings which come within the obſervation of our ſenſes, the ſuppoſition of their not being furniſhed with objects ſuited to their well-being is evidently not

 true,

true, and therefore ought, from analogy, to be rejected with reference to such as by their magnitude, their minuteness, or their dulness of perception, escape our examination.

That animals should feed one upon another, is a law of nature full of wisdom and goodness, life and happiness being indefinitely multiplied thereby. For a given quantity of what are called vegetables, annually produced upon a globe of a given diameter, being sufficient but for the support of a given number of herbaceous animals, whose place in the universe not admitting their immortality, it hath been wisely contrived that their bodies, which from their structure must perish, should, in ceasing to live, become the instruments of supporting life in beings, which could not by any

other means have had an exiſtence, at leaſt upon this globe: and of the other parts of the univerſe we know nothing except from analogy; and from that we muſt conclude that the τὸ πᾶν, be it finite or infinite, is as full of life as this particular part with which we are connected. Nay, animated matter, containing as it were the concentrated virtue of many vegetables, ſerves for the ſupport of life, and the conſequent communication of happineſs in a far more ample manner than vegetables themſelves; animal ſubſtances in equal weights furniſhing more nutriment than vegetable. It is by Death, a ſeeming imperfection in his workmanſhip, that the Deity preſerves vegetable life, ſupports the animal kingdom, daily regulates and renews the œconomy of nature,

 and

and continues this wonderful ſyſtem of things in full youth and vigour, not interrupted by diſeaſe, nor enfeebled by old age.

No objection therefore to the animality of vegetables can be brought from any conſiderations reſpecting their daily deſtruction; for the deſtruction of animals by other animals, the *bellum omnium in omnia*, is an univerſal law of nature, derived from the ſame benevolence to which we attribute creation itſelf. If then every part of the vegetable kingdom hath a degree of perceptivity, however ſmall, there will be a gain of happineſs to the whole ſyſtem; the aggregate may be of a value not to be overlooked by him, to whom the exiſtence of all things is equally poſſible, and from whom all created

exiſt,

existences are equally distant in perfection.

Wherever there is a vascular system, containing a moving nutritive *succus*, there is life; and wherever there is life there may be, for aught we can prove to the contrary, a more or less acute perception, a greater or less capacity for the reception of happiness; the quantity, indeed, of which, after we have descended below a certain degree of sensibility, will (according to our method of estimating things, which is ever partial and relative to ourselves) be small in each individual; yet is the existence of it in the nature of things possible, from the analogy of nature probable: and who can tell whether in a system of nature, confessedly contrived for the production of the greatest possible

ſible good, it may not alſo be neceſſary?

It ſhould be well weighed by the metaphyſicians, whether they can exclude vegetables from the poſſeſſion of the faculty of perception, by any other than comparative arguments; and whether the ſame kind of comparative reaſoning will not equally exclude from animality thoſe animals which are provided with the feweſt and the obtuſeſt ſenſes, when compared with ſuch as are furniſhed with the moſt and the acuteſt. The perception of a man (though it may be doubted whether there are not ſeveral animals which have all the ſenſes more acute) ſeems to be indefinitely greater when compared with that of corallines, ſea-pens, and oyſters, than the perception of theſe, which are allowed to be animals, doth when

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compared with the figns of perception manifefted by a variety of what are called vegetables. Spunges open and fhut their *mamillæ*, corals and fea-pens protrude or draw back their fuckers, fhell-fifh open or keep clofe their fhells in fearch of food or avoidance of injury: it is from thefe and fimilar mufcular motions that we judge the beings to which they belong to have perception, that is, to be animlas. Now in the vegetable kingdom, we may obferve the mufcular motions of many plants to be, to the full, as definite and diftinguifhable as thofe of the clafs of animals juft mentioned. The plants called *Heliotropæ* turn daily round with the fun; by conftantly prefenting their furfaces to that luminary, they feem as defirous of abforbing a nutriment from its rays, as a bed

of

of muſcles doth from the water, by opening their ſhells upon the afflux of the tide. The *Flores Solares* are as uniform in their opening and ſhutting as animals are in their times of feeding and digeſting; ſome in theſe motions do not obſerve the ſeaſons of the year, but expand and ſhut up their flowers at the ſame hour in all ſeaſons; others, like a variety of inſects which appear, or not, according to the heat of the weather or climate, open later in the day, or do not open at all, when they are removed from a ſouthern to a more northern latitude. Trefoil, woodſorrel, mountain ebony, wild ſenna, the African marigold, &c. are ſo regular in folding up their leaves before rainy weather, that they ſeem to have a kind of inſtinct or foreſight ſimilar to that

of ants; which however deserts many of them as soon as they have propagated their kind, by shedding their pollen. Young trees, in a thick forest, are found to incline themselves towards that part through which the light penetrates, as plants are observed to do in a darkened chamber towards a stream of light let in through an orifice, and as the ears of corn do towards the south. The roots of plants are known to turn away with a kind of abhorrence from whatever they meet with which is hurtful to them, and to desert their ordinary direction, and to tend with a kind of natural and irresistible impulse toward collections of water placed within their reach: many plants experience convulsions of their *stamina* upon being slightly touched. Whatever can produce any

any effect upon an animal organ, as the impact of external bodies, heat and cold, the vapour of burning ſulphur, of volatile alkali, want of air, &c. are found to act alſo upon the plants called ſenſitive. But not to inſiſt upon any more inſtances, the muſcular motions of the *Dionæa Muſcipula*, lately brought into Europe from America, ſeem far ſuperior in quickneſs to thoſe of a variety of animals. Now to refer the muſcular motions of ſhell-fiſh, and zoophytes, to an internal principle of volition, to make them indicative of the perceptivity of the being; and to attribute the more notable ones of vegetables, to certain mechanical dilatations, and contractions of parts occaſioned by external impulſe, is to err againſt that rule of philoſophizing which aſſigns the ſame

cauſes

caufes for effects of the fame kind. The motions in both cafes are equally accommodated to the prefervation of the being to which they belong, are equally diftinct and uniform, and fhould be equally derived from mechanifm, or equally admitted as criterions of perception.

I am fenfible that thefe and other fimilar motions of vegetables may by fome be confidered as analogous to the automatic or involuntary motions of animals; but as it is not yet determined amongft the Phyfiologifts, whether the motion of the heart, the periftaltic motion of the bowels, the contractions obfervable upon external impulfe in the mufcles of animals deprived of their heads and hearts, be attributable to an irritability unaccompanied with perceptivity, or to an uneafy fenfation, there

there seems to be no reason for entering into so obscure a disquisition; especially since irritability, if admitted as the cause of the motions of vegetables, must, *a fortiori*, be admitted as the cause of the less exquisite and discernible motions of beings universally referred to the animal kingdom.

Physical observations concerning the generation, nutrition, organization, life, health, sickness, and death of plants, help us as little towards the establishing a discriminative characteristic between them and animals, as metaphysical speculations relative to the quantity of happiness, or degrees of perceptivity.

The eastern practice of fœcundating the female palm-tree by shaking over it the dust of the male, which Herodotus mentions in his account of

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the country about *Babylon*, and of which Dr. *Hasselquist* in the year 1750 was an eye witness, was not unknown to *Aristotle* and *Pliny*: but the ancients seem not to have carried the sexual system beyond that single instance, which was of so remarkable a kind, that it was hardly possible for them to overlook it; at present there are few botanists in Europe who do not admit its universality. It seems generally agreed, that a communication of sexes, in order to produce their like, belongs to vegetables as well as to animals. The disputes subsisting among the anatomists, concerning the manner in which conception is accomplished, whether every animal be produced *ab ovo femellæ*, or *a vermiculo in semine maris*, are exactly similar to those amongst botanists concerning

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the manner in which the *farina fæcundans* contributes to the rendering the feed prolific: but however these doubts may be determined, they affect not the present inquiry, since it is allowed on all hands, that, as the eggs of oviparous animals, though they arrive at their full magnitude, are incapable of being vivified by incubation, unless the female hath had commerce with the male: so the dates of female palm trees, and the fruits of other plants, though they ripen, and arrive at maturity, will not grow unless they have been fœcundated by the *pollen* of the male.

In like manner, notwithstanding the diversity of opinion which hath long subsisted, and in a matter so little capable of being enlightened by experiment, probably ever will subsist,

ſubſiſt, concerning the *modus agendi* by which nature elaborates the nutritive fluid, adminiſters it to the fœtus in the womb, and produces an extenſion of parts; yet ſince a *placenta* and an umbilical chord are by all thought eſſential to the effecting theſe ends; and ſince the cotyledons of plants, which include the *corculum* or firſt principle of the future plant, with which they communicate by means of tubes branched out into infinite ramifications, are wholly analogous to the placenta and umbilical chord of animals, we have great reaſon to ſuppoſe that the embryo plant and the embryo animal are nouriſhed and dilated in their dimenſions after the ſame way. This analogy might be extended and confirmed by obſerving that the lobes, within which the fœcundated germ

is placed, are by putrefaction converted into a milky fluid, well adapted as an aliment to the tender ſtate of the plant.

Exſpiration and inſpiration, a kind of larynx and lungs, perſpiration, imbibition, arteries, veins, lacteals, an organized body, and probably a circulating fluid appertain to vegetables as well as to animals. Life belongs alike to both kingdoms, and ſeems to depend upon the ſame principle in both: ſtop the motion of the fluids in an animal limb by a ſtrong ligature, the limb mortifies beyond the ligature, and drops off; a branch of a tree under like circumſtances, grows dry, and rots away. Health and ſickneſs are only other terms for tendencies to prolong or to abridge the period of life, and therefore muſt belong to

both

both vegetables and animals, as being both poſſeſſed of life. An eaſt wind, in our climate, by its lack of moiſture, is prejudicial to both; both are ſubject to be froſt-bitten, and to conſequent mortifications; both languiſh in exceſſive heats; both experience extravaſations of juices from repletion, and pinings from inanition; but can ſuffer amputation of limbs without being deprived of life, and in ſimilar manner both form a *callus*; both are liable to contracting diſeaſes by infection; both are ſtrengthened by air and motion: *Alpine* plants, and ſuch as are expoſed to frequent agitation from winds, being far firmer and longer lived than thoſe which grow in ſhady groves, or hot-houſes; both are incapable of aſſimilating to their proper ſubſtance all kinds of food;

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for fruits are found to taste of the soil, just as the urine, and milk, and flesh, and bones of animals, often give indications of the particular *pabulum* with which they have been fed: both die of old age, from excess of hunger, or thirst, from external injuries, from intemperature of weather, or poisoned food.

Seeds of various kinds retain their vegetative powers for many years: the vivification of the *ova*, from which the insects occasioning the smut in corn, and the *infusoria animalcula* observable in water after the maceration of plants, probably proceed, may be esteemed a similar phænomenon. It is not yet clearly decided amongst naturalists, whether the seeds of mushrooms, of mucors, and of the whole class of *Fungi* be not in a tepid, humid *matrix*,

changed

changed into vermicular animals, which loſe in a little time their power of ſpontaneous motion, coaleſce together, and grow up into theſe very ſingular plants: the quickneſs of their increaſe, and the irreſiſtible force with which the leaſt mouldineſs propagates itſelf, and deſtroys the texture of the bodies upon which it fixes, ſeem to point towards an animal nature.

Different vegetables require different ſoils, as different animals do different food for their ſupport and well being: aquatics pine away in dry ſandy grounds, and plants which love rocks and barren ſituations, where they imbibe their chief nutriment from the air, become diſeaſed and putrid in rich bogs and ſwamps.

There are aquatic animals which become immovable and lifeleſs

when the rivulets in which they subsisted happen to be dried up, but which recover their life and locomotive powers upon the descent of rain: in this circumstance they are analogous to the class of mosses among vegetables, which, though they appear to be dried up, and ready to crumble into dust during the heats of summer, yet recover their verdure and vegetable life in winter, or upon being put into a humid soil.

Trembley, *Bonnet*, and *Spallanzani* have vastly amplified our views of nature; they have discovered to us divers species of animals, which may be cut into a variety of pieces without losing their animal life, each piece growing up into a perfect animal of the same kind: the multiplication of vegetables by the planting of

of branches, ſuckers, or joints of roots, is a ſimilar effect. The reproduction of the legs of craw-fiſh, lobſters, crabs, of the horns and heads of ſnails, legs of lizards, of the bony legs and tails of ſalamanders, when by accident or deſign they have been deprived of them; and the great difference in the time of the reproduction, according to the ſeaſon of the year in which the limb is loſt, are wonders in the animal kingdom, but wholly analogous to the repullulation of trees after lopping.

All plants, except thoſe of the claſſes *Monæcia* and *Diæcia*, are hermaphrodites; that is, they have the male and female organs of generation within the ſame empalement. Shell-fiſh, and ſuch other animals as reſemble vegetables in not being able

able to move far in ſearch of mates, with which they might propagate their kind, are hermaphrodites alſo: *Reaumur* hath proved that vine fretters do not want an union of ſexes for the multiplication of their kind.

From the conjunction of animals of different ſpecies are produced *hybrides*, which in many caſes cannot propagate: botaniſts have tried the experiment, and by fœcundating female flowers with the male duſt of another ſpecies, have produced hybridous plants, of an intermediate ſhape, the ſeeds of which are barren and effete.

Trees ſhed their leaves as birds do their feathers, and hirſute animals their hair. At particular ſeaſons the juices of vegetables move with fulneſs and vigour; at others they are leſs plentiful, and ſeem to

ſtagnate;

ſtagnate; and in this they reſemble dormice, bats, frogs, and numberleſs other animals of cold blood, which lie torpid and deſtitute of every ſign of life during the winter time; the action of the lungs and of the heart being, if any, imperceptibly weak and languid.

Few, if any animals can exiſt without a reciprocal ſucceſſion of ſleep and vigilance, and the younger the animal, the greater is its propenſity to ſleep: the ſame alternatives ſeem neceſſary for the health of ſeveral vegetables; a great variety of plants fold up their leaves, and ſeemingly compoſe themſelves to reſt, in the night time, and this diſpoſition for ſleep is more remarkable in young plants than in old ones; nor does it, as might be ſuſpected, depend upon the influence of light or

or heat, ſince plants in hot houſes, where the heat is kept at the ſame degree, fold up their leaves at a ſtated time in the evening, and expand them in the morning, whether the light be let upon them or not. It may deſerve to be enquired, whether by a relaxation of fibres theſe plants become ſubject to a more copious perſpiration during ſleep than in their ſtate of vigilance, as *Sanctorius* hath proved to be the caſe in animals.

There is a great diverſity, but a regular ſucceſſion, in the times in which animals of different ſpecies feel the *æſtrum*, by which they are ſtimulated to the propagation of their reſpective kinds; an order equally determined, is obſervable in the times of accompliſhing the *ſponſalia* of plants. The periods of incubation

cubation in oviparous, and of geſtation in viviparous animals, are not more various in different ſpecies, nor probably more definite in the ſame, than the periods requiſite for the germination and maturation of different ſeeds. By the influence of heat and cold, abundance and ſcarcity of nouriſhment, the ſeaſons of propagating may be ſomewhat accelerated or retarded in animals as well as in vegetables: the effects of a cold ungenial ſpring are as remarkable in the retardation of the procreative intercourſes of birds and beaſts, as in the ſtoppage of the leafing of trees, or the flowering of ſhrubs. In a word, there are ſo many circumſtances in which the anatomy and phyſiology of ſome plants agree with thoſe of ſome animals, that few, I believe, can

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be mentioned in which they disagree.

When it is considered that animals are either mediately or immediately wholly nourished from vegetables, it might be expected, *à priori*, that the products obtainable by a chymical analysis from the two kingdoms should be different rather in quantity than quality, and that we could not from thence discover any criteria by which they might be distinguished from one another: this observation is confirmed by experiment. Animals, it is true, in general yield a greater proportion of a volatile alkaline, than of an acid salt by distillation; vegetables on the contrary abound in acid, and yield not any volatile alkali, unless with the last degree of heat, or when they have undergone putrefaction:

in ſaying this, I am aware that I differ from the opinion commonly received. Muſtard ſeed, water creſſes, horſe radiſh, and other plants of the *tetradynamia* claſs are generally ſaid to contain a volatile alkali already formed, and to yield it with the heat of boiling water; from none of theſe however could I ever obtain by that heat a phlegm which would give a precipitation with corroſive ſublimate, the moſt indubitable teſt of a fluid's containing even the minuteſt portion of volatile alkali; the pungent ſmell ſeems to have been miſtaken here, as *Sir John Pringle* hath well obſerved the *fætor* to have been in the putrefaction of many animal ſubſtances, as proceeding from a volatile alkali; and which may, perhaps, be with greater truth attri-

buted

buted to a volatile oil, a ſmall portion of which is ſometimes procurable from pepperwort, by the heat of boiling water impregnated with ſea ſalt. However, as ſome animals, and ſome parts of moſt animals, yield a portion of acid, and as moſt vegetables, by a ſtrong fire in cloſe veſſels, or when converted into ſoot, afford a volatile alkali, altogether ſimilar to that obtained from animal ſubſtances, we cannot from theſe circumſtances eſtabliſh any diſtinctive mark between the two kingdoms.

With reſpect to Minerals indeed, chemiſts think that they have found out an infallible and univerſal criterion, by which they may be diſtinguiſhed from every animal or vegetable ſubſtance. All bodies from which we can obtain an oil by diſtillation,

tillation, or otherwiſe, are ſuppoſed to belong to ſuch ſubſtances as have enjoyed an organic life; no mineral, it is ſaid, containing any: this is a ſenſible diſtinction, and yet it is not perhaps in extreme caſes wholly to be relied upon. When a vegetable or animal is diſtilled in cloſe veſſels, the ſtronger the fire is, the more oil is obtained; what firſt paſſes into the recipient is more clear and limpid than what comes over towards the end of the operation: it may be preſumed, however, that what remains adherent to the coal in the retort, and which no violence of fire can ſeparate, is not eſſentially different from the laſt portions which are diſtilled; yet this, be it fixed oil or phlogiſton, is nowiſe different from what enters into the compoſition of metallic ſubſtances, and of mi-

minerals, perhaps, of all kinds. Zinc burns with a flame resembling that of charcoal; lead and tin burn like rotten wood; iron and other metals may be burnt to ashes in the open air, but like charcoal cannot be decomposed in close vessels; spirits of wine burn like sulphur, charcoal and metallic substances without producing any soot; yet from spirits of wine an oil may be obtained. Why should the phlogiston of metals be thought of a nature wholly different from the oil which so obstinately adheres to charcoal, or from that which seems to enter into the composition of vinous spirits?

Naturalists, as well as chemists, have perhaps too precipitately embraced the opinion, that minerals may be certainly and readily distin-

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guiſhed from the other two kingdoms. A vaſcular ſyſtem, a nutritive ſuccus, and a power of producing its like, conſtitute the abſtract idea both of a vegetable and an animal, as contradiſtinguiſhed from a mineral: this idea is clear and definite in itſelf; but to determine how far the coexiſtence of theſe qualities is in the nature of things neceſſary, or where any of them ceaſes to exiſt, is a queſtion of vaſt difficulty when applied to particular caſes. Stones dug out of quarries, ores out of mines, in general, minerals ſeparated from their *matrices*, are like the dead branches or limbs of vegetables or animals, incapable of receiving increaſe, except from an external incruſtation; but whether the matrices themſelves increaſe, or, that being in ſome caſes granted,

whether they receive their augmentation from an external appofition, or an internal affimilation and extenfion of parts, cannot readily be decided either way. In the *Cretan* labyrinth it hath been obferved, that the names of travellers, which have been cut in the rock in former ages, are now in *alto relievo*, and that the older the dates are, the greater is the protuberance, refembling the callus formed by incifions in trees. In the mines of *Chremnitz* in Hungary, which have been wrought for above one thoufand years, the ancient roads which had been cut through the rocks are left to grow up; and it is remarked, that they approach one another in a horizontal, and not in a perpendicular direction; the fame phænomenon may be obferved in the marble

ble quarries in *Italy*, as is mentioned by *Baglivy* in his Treatiſe upon the Vegetation of Stones: but whether theſe, and many ſimilar appearances are to be attributed to the preſſure of the ſuperincumbent ſtrata, or to a kind of vegetable growth, is a doubtful point. Rock cryſtals, amethyſts, and various precious ſtones have been thought by *De Boot* and others to grow like muſhrooms; certain it is, that they often contain in them ſeveral heterogeneous particles; a circumſtance which proves them to have been once in a fluid ſtate, and induces a ſuſpicion that in their formation they may reſemble the gums and reſins extravaſated from various ſpecies of vegetables. The vegetation of ſtones hath been admitted by many, and ſome have contended that minerals, as well as ani-

animals and vegetables, ſpring from ſeed, the greateſt rock being nothing but the expanſion of the parts of a minute grain of ſand.

Salts diſſolved in water conſiſt of indefinitely ſmall *moleculæ*, which, as far as microſcopes can inform us, are ſimilar in figure to the large cryſtals which become viſible to the naked eye, and which are formed, as it were, from the expanſion of one particle: it will be eaſily underſtood how conformable this mineral cryſtallization is to the opinion of thoſe, who attribute the growth of animals and vegetables to the *accretion of organic particles* of the ſame kind. The concentrick cruſts of which *ſtalactites* conſiſt, are not either in their appearance, or their formation, perhaps, unlike the circles annually produced by the ſtagnation

nation of the ſap in the boll and branches of trees. The native gold and ſilver tufts, which appear to burſt through the hardeſt rocks, and which, from their great reſemblance to trees, have been called by ſome arboreſcent, ſeem to indicate a kind of vegetation in their formation.

Suppoſing, however, that we pay no attention to any of theſe circumſtances, yet cannot we form any judgment concerning the internal ſtate of the earth. The greateſt depths to which miners have penetrated even in mountainous countries, which may be conſidered as excreſcences from the true ſurface of the earth, or the level of the ſea, have ſcarcely ever equalled one ſixteen thouſandth part of its diameter; a diſtance altogether inſufficient for the forming any probable conjecture

about the inward conſtitution of the globe. The *ſtrata* of ſtones, and veins of minerals, which are met with upon the ſurface, can give us as little information concerning the internal ſtructure of the earth from which theſe are probably derived, as the contemplation of the ſcales of a fiſh, the feathers of a bird, or the *epidermis* of a man, would concerning the bones and muſcles, the veins and arteries, the circulation of the blood, and the ſeveral ſecretions of an animal body. Many minerals ſeem in their formation to have been antecedent, others ſubſequent to the univerſal deluge; a great part of the matter conſtituting the outward ſhell of the earth, the only part which we can examine, hath been ſubſervient to vegetable or animal life. All the *ſtrata* of limeſtones, chalks, marbles,

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all gypſums, ſpars, alabaſters, &c. are confeſſedly of animal origin. The *ſtrata* of pit-coal, and of all bituminous foſſils, of ſome ſpecies of ſlates, whatever may be thought of argillaceous ſtrata in general, the mould every where covering the ſurface of the earth, and other ſubſtances, are ſuppoſed, probably enough, to have ariſen from the deſtruction of vegetables; ſo that I know not whether it would be a very extravagant conjecture which ſhould ſuppoſe that all matter is, or hath been, organized, enlivened, animated.

Hence may it appear probable, with reverence yet, and conſcious ignorance be it ſpoken, that the *One, Eternal, Incomprehenſible God* hath eſtabliſhed an uninterrupted concatenation in all his works, which he hath

hath ſubmitted to our view. Different individuals hath he mingled together into the ſame *ſpecies*; different ſpecies into the ſame *genus*; different *genera* into the ſame kingdom; and different kingdoms he hath diſtinguiſhed, perhaps, but by lines of diviſion too minute for our obſervation. This ſtrong analogy by which men and minerals, and all intermediate exiſtencies, are bound together in a common chain, and thence, it would ſeem, naturally ſubjected to a common fate, may appear humiliating to ſuch as have been wont to entertain high notions of the phyſical dignity of human nature: but it cannot offend nor diſquiet thoſe, who feel within themſelves faculties eſſential to the conſtitution of moral agency, and who from thence become capable at leaſt of retribution,

of punishment, or reward, in another state.

In the number of our senses, and in the modifications of the intellectual faculties which spring therefrom, we have a great resemblance to many animals which inhabit this planet as well as we. The *genus* to which man belongs includes a great many subordinate *species*; or, to speak in a manner more conformable to nature, and more consonant to the account we have of its origin, the human species, from the diversities of climate and of food, from changes introduced by disease, and continued, perhaps, by propagation, and from other causes which are unknown to us, hath been branched out into a great many varieties: these, however, are as much distinguished in shape and intellect from one

one another, as they are from animals which have ſprung from a different ſtock. Anatomiſts, *whether they conſider the brain as an inſtrumental, or an efficient cauſe of intelligence,* are agreed in acknowledging a great reſemblance between the contents of the human *cranium* and thoſe of quadrupeds; and *Putius* hath proved, contrary to the opinion embraced by *Pliny*, and commonly received, that we have not that medullary ſubſtance in a greater proportion than other animals. Nor are we characterized by a circumſtance generally eſteemed eſſentially neceſſary to the ſupport of the human fœtus, and excluſively appertaining to our ſpecies: nations are mentioned to whom it doth not belong; and whatever degree of credit may be given to that narration, it

is certain that a great many ſpecies of animals have been diſcovered to which it doth. Notwithſtanding this analogy by which we are to be claſſed with the reſt of the animals around us, yet hath it pleaſed Him who called forth from nothing both us and them, and thankful we ought to be for the preference, to place us at the top of the ſcale, to make us, as it were, the firſt term of a ſeries, deſcending indefinitely by imperceptible gradations, to particularize that claſs of animals to which we belong, by rendering it capable of forming a moral character. This capability, it is true, is various according to the opportunities of, and capacities for, receiving inſtruction in different ſpecies, and in different individuals of the ſame ſpecies: the Orang-outang of the woods of Java,

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the apron-bellied Caffre of the Cape *, the woolly-headed Negro of Africa, the beardleſs Savage of America, the dwarfiſh Inhabitant of the Frigid Zone, the moon-eyed Albino, and the enlightened European, are as different from one another in this circumſtance as in outward form: yet wherever it exiſts even in the ſmalleſt degree, there ariſeth a pro-portionable

* Since the writing of this Eſſay it has been diſcovered by Profeſſor *Sparmann*, that the epithet here applied to the Caffres, on the authority of former Voyagers, is not juſt; and it is now alſo believed, on good authority, that the Savages of America would reſemble Europeans in having beards, if they did not pluck out the hairs by the roots as ſoon as they begin to appear. If the reader wiſhes to ſee an account of the principal varieties of the human race, he may conſult *Van Berchem's Tableau*, publiſhed in the Memoires de Lauſanne, 1785.

portionable imputability of conduct, a kind of title to the natural or covenanted good, a reasonable subjection to the natural or positive evil, which God hath annexed as sanctions to the laws which he hath thought fit to prescribe for the regulation of the moral conduct of mankind.

ESSAY IV.

Some Remarks on the Effects of the Cold in February, 1771.

ON the 12th of February, 1771, about an hour after ſun-riſing, I obſerved at Cambridge a degree of cold which is very unuſual in England, though common enough in more northern climates. *Fahrenheit*'s thermometer, made by *Dolland*, as well in the open air, as when covered with ſnow, ſtood as low as 6° above 0. The *Cam*, by no means a rapid river, remained unfrozen; at the ſides indeed there was a little ice, and ſome ſmall flakes floating in the

middle. This is no very uncommon phænomenon. The *Seine* was not frozen at *Paris* in 1709, though the cold continued for two days one degree greater than in the preſent caſe. Various reaſons have been produced, in order to account for this ſeeming deviation from the uſual courſe of nature. It hath been generally believed, that the ſtrong current in the *Seine* impeded the congelation: motion will certainly hinder the parts of fluid bodies from acquiring a regular arrangement; but it may be doubted whether it will wholly prevent their coaleſcence, in any caſe where the degree of heat is leſs than what would keep them fluid if they were quieſcent. We have frequent inſtances in chemiſtry, of ſaturated ſolutions of ſalts remaining perfectly fluid whilſt at reſt,

and

and of forming thick coagulums upon the leaſt motion. Melted metals, glaſs, reſins, &c. appear to continue fluid for a longer time, after being taken from the fire, by having their parts moved, than if they are left at reſt; becauſe the ſuperficies which is expoſed to the air is conſtantly changing, and the whole maſs becomes uniformly cold and fixed at once, as ſoon as it has parted with the heat neceſſary for its fuſion. The moſt rapid rivers would probably experience a ſimilar change, did the cold in the atmoſphere continue long enough to be communicated to the whole body of the water: for upon taking the thermometer out of the ſnow, which laid upon the bank of the river, and immerſing it into the water, it ſuddenly roſe 26°, and ſtood at 32°, or higher; ſo that the

air was very considerably colder than the water: nor is this at all to be wondered at, when we consider that great degrees of cold may be suddenly produced in the atmosphere by causes which do not immediately operate upon other bodies. Thus the influx of colder air from the northern latitudes, or the descent of that which always remains exceedingly cold in the upper parts of the atmosphere in the same latitude, may in a few hours wholly change the air of a particular district: or, if from any peculiar circumstance the air should become unusually dry, and consequently disposed to dissolve much water, a great degree of cold might be almost instantaneously produced; but which could not be communicated to other bodies, in a little time, by so rare a fluid as the air.

During

During the forementioned degree of cold, a thick vapour was ſeen riſing from the ſurface, and marking as it were the courſe of the river. If we attribute the elevation of this vapour to the attraction of the air, rather than to the comparative warmth of the water (for water juſt beginning to freeze is obſerved not to loſe of its weight by evaporation *in vacuo*), the great cold may be thought perhaps to have proceeded from the ſolution of water in air which was then carrying on; for the earth was glutted with humidity, and the air was become dry, having been freed from its water by an almoſt inceſſant precipitation for three days, under the form of ſnow or ſleet. It is very remarkable, that the extreme cold of January 13, 1709, came on at *Paris*, with a gentle ſouth wind,

and was diminiſhed when the wind changed to the north; this is accounted for by M. de la *Hire*, from the wind's having paſſed over the mountains of *Auvergne* to the ſouth of *Paris*, then covered with ſnow; and by Mr. *Homberg*, from the reflux of that air, which had been flowing for ſome time from the north. I do not ſee from what philoſophical principle it can be ſuppoſed, that the ſame air in its regreſs from a ſouthern latitude ſhould be colder than in its progreſs from a northern; and as to the other opinion, the phænomenon of the cold's increaſing upon the wind's changing from north to ſouth, hath been taken notice of in other places, where there was no ſnow to refer it to. May it not deſerve to be conſidered, whether the ſudden ſolution of large quantities

tities of aqueous vapours, brought from the ſouth into a dry northern air, be not a cauſe adequate to the effect produced? The ſolubility of water in air is diſtinctly mentioned by Dr. *Halley*, in the Philoſ. Tranſ. N° 192; and in the 6th Vol. of the *French* Encyclopedie, publiſhed in 1756; and more fully and ingeniouſly treated of by Dr. *Hamilton* in 1765: the cold attending the ſolution is a phænomenon ſimilar to that attending many other chemical ſolutions, and is in a leſs degree ſenſibly felt by every one who goes into a room newly waſhed, or ſtreet in the ſummer-time lately watered.

Upon taking the thermometer out of the river, its bulb was quickly covered with a thin cruſt of ice, which defended it ſo much from the cold ſubſiſting in the atmoſphere,

 that

that it did not ſink two degrees in ten minutes; whereas, when it was wiped dry after immerſion in water, it ſunk above 20° in a leſs ſpace of time: this circumſtance ſhews that ice doth not tranſmit cold, and is explained by the experiments of M. *Richmann*, who hath eſtabliſhed it as a principle, that metallic ſubſtances are far more quickly affected in their dimenſions by the tranſitions from heat to cold, and the contrary, than any other bodies yet known.

Being deſirous of obſerving the effect of this extraordinary degree of cold upon various ſaline ſolutions, I haſtened to my elaboratory, where I happened to have a great many ſolutions of ſalts corked up in quart bottles; the bottles were not all full, but the ſolutions were perfectly ſaturated; the ſtate in which I found

them is expressed in the following Table.

Frozen wholly,

Alum
Cream of tartar
Arsenic
Corros. sublimate
Borax
Nitre

Frozen nearly,

Green vitriol
Blue vitriol
Rochelle salt
Glauber's salt genuine
White vitriol, a few glacial spicula

Wholly fluid,

Sea salt
Sal gemmæ
Sal ammoniac

Volatile

Volatile alkaline ſalt
Fixt alkali per deliq.
Epſom ſalts } Lymington.
Glauber's ſalts } Lymington.

Theſe experiments agree upon the whole very well with thoſe of Profeſſor *Braunius*, related in the *Peterſburgh* Commentaries for 1763: for, though his ſaturated ſolutions of *Epſom* ſalts, and of fixt alkali, had begun to freeze in a leſs degree of cold, yet it is probable that his *Epſom* ſalts might have been different from thoſe manufactured at *Lymington*, and the ſolution of his fixt alkali not ſo well ſaturated as that which is made per deliquium.

During the ſame froſt, I endeavoured to find out the powers, by which different ſalts, when they are diſſolved in water, reſiſt congelation.

tion. With this view I diſſolved equal weights of ſalts, equally dry, in equal quantities of water, and expoſed the ſolutions, when they were arrived at the ſame degree of heat, in veſſels of equal and ſimilar figures to the ſame freezing atmoſphere; and accurately marking the times in which they began to freeze, I found them obſerving the following order: firſt alum, then Rochelle ſalt, green vitriol, ſugar refined, white vitriol, vitriolated tartar, Glauber's ſalt, mineral fixt alkali, nitre, blue vitriol, volatile alkali, ſal ammoniac, laſt of all, ſea ſalt. Theſe experiments were repeated once or twice with ſome attention; yet I would not be thought to propoſe the order in which I have arranged the ſeveral ſalts, as wholly to be relied on. It were to be wiſhed, that a

ſufficient

ſufficient number of experiments were accurately made upon this ſubject; ſome general truths relative to metallic earths, and alkaline neutral ſalts, would probably be obtained therefrom, which, however unimportant in themſelves, might ſerve, upon ſome occaſion or other, as connecting links, to extend the chain of our ideas. By this compariſon of equal quantities of different ſalts diſſolved in equal quantities of water, we might be enabled to ſpeak with as much preciſion, concerning the powers by which they reſiſt congelation, as we do concerning thoſe by which they reſiſt putrefaction. I know not whether it may not be thought too curious a remark to obſerve, that the ocean is impregnated with that ſpecies of ſalt which reſiſts congelation with the greateſt power, and

and in ſuch a quantity as tends not to preſerve entire, but to accelerate the diſſolution of the numberleſs animals which are daily dying in it. *Beccher*, it hath been aſſerted, was acquainted with this property of common ſalt; but he ſeems only to ſpeak of it as a far leſs efficacious antiſeptic than ſugar; at leaſt, the honour of aſcertaining the proportion in which it acts as a ſeptic undoubtedly belongs to Sir *John Pringle*; for *Beccher*, in his *Phyſica Subterranea*, *lib.* I. *ſect.* v. *cap.* 1. where he is ſpeaking of this matter, ſays, "*Quod nimius ſalis uſus corpus putreſcere faciat, ſicut modicus a putredine præſervat.*"

To a table exhibiting the relative powers of neutral ſalts in reſiſting congelation, another might be uſefully added, denoting the powers of

all the known acids and alkalis when diluted to a given denſity; as alſo of vinous ſpirits, from highly rectified ſpirits of wine to water impregnated with the minuteſt quantity of ſpirit. Not but that it may be conjectured *a priori*, that in this laſt caſe the reſiſtance to congelation would be directly as the quantity of ſpirit contained in given quantities of water. I made an experiment of this kind with ſea ſalt: in equal quantities of water were diſſolved quantities of ſea ſalt, increaſing in the arithmetical progreſſion, 0, 5, 10, 15, 20, &c.; the times in which the ſolutions began to freeze, reckoning from the time in which ſimple water began, increaſed accurately in the ſame progreſſion: hence it may be inferred, that, in ſalt of the ſame kind, the reſiſtance to congelation is

in the direct ſimple proportion of the quantity of ſalt diſſolved: this concluſion cannot be extended to ſalts of different kinds, ſince water ſaturated with ſea ſalt is more difficultly congealed than when ſaturated with various other ſalts, which it diſſolves in greater quantities.

ESSAY V.

Account of an Experiment made with a Thermometer, whose Bulb was painted black, and exposed to the direct Rays of the Sun.

DURING the hot weather, which we had in the latter end of June and the beginning of July, 1772, I made an experiment at *Cambridge*, which I then thought no more of, but which an accident hath brought to my mind again; and I now venture to relate an account of it, in hopes that some philosophical friend will take the trouble of prosecuting it. I exposed the bulb of an excellent thermometer to the direct rays of the sun, when the sky was perfectly free from clouds; the

mercury roſe to 108° of *Fahrenheit's* ſcale, and continued ſtationary. A fancy ſtruck me, to give the bulb a black covering; this was eaſily effected by a camel's hair pencil and *Indian* ink; the mercury ſunk a few degrees during the application of the coating, and the evaporation of the water; but preſently after roſe to 118°, or 10° in conſequence of the black coat with which I had covered that part of the bulb which was expoſed to the ſun. If the bulbs of ſeveral correſponding thermometers were painted of different colours, and expoſed at the ſame time to the ſun, for a given period, ſome conjectures, reſpecting the diſpoſition of the ſeveral primary colours for receiving and retaining heat, might be formed, which could not fail of being, in ſome degree, intereſting.

TRACT VI.

Plan of Chemical Lectures, 1771.

INTRODUCTION.

HISTORY of chemiſtry, and of alchemy.

Of the elements of chemiſtry commonly received — Earth, air, fire, water.

Conjectures concerning the mutual convertibility of chemical elements.

Of the ſolidity, fluidity, fixity, and volatility of bodies in different degrees of heat.

Conjectures concerning the formation and nature of the atmoſphere.

 Calcina-

Calcination, ſublimation, evaporation, diſtillation *per aſcenſum*, *per retortam*, *per deſcenſum*, explained and exemplified.

Of the different degrees of heat required for the conducting of different operations: the terms *venter equinus*, *balneum maris vel mariæ*, *balneum vaporis*, *capella vacua*, *balneum cinerum*, *arenæ*, *limaturæ ferri*, explained.

The heat of boiling homogeneous fluids in open veſſels, ſhewn to be incapable of increaſe from an increaſe of fire.

The heat of boiling homogeneous fluids ſhewn to be greater or leſs, within certain limits, in proportion to the augmentation or diminution of the preſſure of the atmoſphere, or other elaſtic fluid upon their ſurface.

A fluid contained in a veſſel ex-

posed to the action of boiling water for any length of time, does not acquire the heat of boiling water unless it come in immediate contact with it.

The heat of boiling oil ascertained, and the use of a *balneum olei* illustrated.

The structure and use of simple, reverberatory, melting, cupelling and other furnaces explained.

The nature of the inflammable principle, *pabulum ignis*, or phlogiston, inquired into from the phænomena attending the combustion of vegetable oil, animal fat, vinous spirits, charcoal, and metallic substances.

The earth obtained from the combustion of the phlogiston of metallic substances converted into its primary metallic appearance by the

addition of phlogiſton; exemplified in the reduction of the flowers of zinc by charcoal, and of minium by charcoal, by animal fat, and by iron filings.—The identity of phlogiſton inferred from the preceding experiments.

Definition, and general diviſion of ſaline ſubſtances into acid, alkaline, and neutral ſalts.

Acid ſalts diſtinguiſhed commonly from alkaline and neutral ſalts by their taſte; by efferveſcing with calcareous earths; and by changing the blue colour of ſyrup of violets, and other blue vegetable infuſions into a red.

Alkaline ſalts diſtinguiſhed from neutral ſalts by taſte; by efferveſcing with acids; and by changing the blue colour of ſyrup of violets into a green.

A neutral

A neutral ſalt made from a mixture of an acid and an alkali.----The term ſaturation explained.

The vegetable fixed alkali extracted from the aſhes of charcoal by ſolution and filtration ; and from tartar by combuſtion—Pearl-aſh----Pot-aſh—Salt of tartar.

Salt of tartar rendered liquid by expoſure to the air, improperly in that ſtate called oil of tartar *per deliquium.*

Quantity of water attracted from the air by a given quantity of ſalt of tartar, in a given time, eſtimated by experiment.

The mineral fixed alkali extracted from the aſhes of the plant kali, jointed glaſs-wort, marſh ſamphire, or *ſalicornia* of *Linnæus*, and from ſea tangle, &c. by ſolution and fil-

tration, and its difference from the vegetable fixed alkali shewn.

Volatile and fixed alkalis distinguished from each other by the smell, and by the different colours produced in mixing them with a solution of corrosive sublimate. — Uncertainty of this criterion remarked.

OF MINERALS.

Of the Pyrites and green Vitriol.

Natural history of the pyrites.

Sulphureo - ferrugineous pyritæ from the chalk-pits of *Cherry hinton* analysed by distillation—Sulphur—Ferrugineous residuum: method of assaying any particular species of the pyrites for sulphur.

Analysis of sulphur by combustion — Phlogiston — Volatile sulphureous acid: method of obtaining the acid

acid of sulphur at *Battersea*, and in other places.

Iron-pyritæ desulphurated by roasting.

Green vitriol extracted from the desulphurated iron-pyritæ by elixation and crystallization: method of assaying any particular species of the pyrites for green vitriol.

Iron-filings, sulphur, and water kneaded together: Intumescence — Incalescence—Incension of the mixture.

Conjectures concerning the origin of subterraneous fires and volcanos founded upon the preceding experiment.

Green vitriol extracted from the residuum of the preceding experiment.

Of the weathering, or spontaneous decomposition and simultaneous vitriolization, of the pyrites.

Various

Various ſpecies of the pyrites exhibited in a vitriolizing ſtate.

Green vitriol extracted from vitriolized pyritæ.

Account of the principal green vitriol works in *Great Britain.*

Native green vitriol ----*German*—*Engliſh.*

Method of purifying green vitriol from copper, and of diſcovering whether it contains copper.

Green vitriol calcined to a white, yellow, and red colour.

Calcined green vitriol analyſed by diſtillation—vitriolic acid—ferrugineous *reſiduum* or colcothar.

Of the vitriolic Acid and its Combination with Water, with fixed, and with volatile alkaline Salts.

The vitriolic acid of the preceding proceſs concentrated, or rectified by

by diſtillation: Weak acid, commonly called ſpirit of vitriol—Reſiduum, ſtrong acid, improperly called oil of vitriol.

Degree of heat ariſing from the mixture of oil of vitriol and water obſerved by a thermometer: proportions producing a *maximum* of heat aſcertained by experiment.

Quantity of water attracted from the air by a given quantity of oil of vitriol, in a given time, eſtimated by experiment: uſe of oil of vitriol as an hygrometer.

Specific gravity of oil of vitriol determined.

Equal bulks of oil of vitriol and water mixed together: ſpecific gravity of the mixture not equal to the mean ſpecific gravity of the two fluids.

Dr. *Hook*'s experiment, concerning

ing the penetration of dimenſions in the mixture of oil of vitriol and water, conſidered.

Vitriolic acid not abſorbed into the pores of water, as *Muſſchenbroek* and others have ſuppoſed.

Acid of vitriol combined with the fixed alkaline ſalt of tartar—*Tartarus vitriolatus* made after *Tachenius*'s manner.....General properties of vitriolated tartar.

Sir Iſaac Newton's theory concerning chemical attraction ſtated and explained — *Geoffroy*'s, *Gellert*'s, and other tables of affinity explained.

Acid of vitriol combined with the fixed alkaline ſalt of kelp — *Glauber's ſal mirabilis*—General properties of Glauber's ſalt.

Acid of vitriol combined with volatile alkali — *Sal ammoniacus ſecretus*

cretus Glauberi; general properties of this ſalt.

Of the Combination of the vitriolic Acid with Earths.

Acid of vitriol combined with earth of *ſal catharticus amarus* — Hiſtory of *Epſom* ſalts.

Acid of vitriol combined with argillaceous earths—Alum.

Natural hiſtory of aluminous ores.

Schiſtus aluminoſus crude, and calcined, from Yorkſhire and Lancaſhire.

Account of the principal alum works in England.

Method of aſſaying aluminous mineræ.

Alum calcined·····*Alumen uſtum.*

Alumen uſtum diſſolved in water and cryſtallized.

Analyſis

Analyſis of alum by diſtillation—Vitriolic acid—Reſiduum.

Analyſis of alum by precipitation with fixed alkaline ſalt of tartar----Vitriolated tartar—Earth of alum.

Account of the experiments of *Marggraf* and *Macquer* upon the earth of alum.

Nature of argillaceous earths—Conjectures concerning the identity of argillaceous and vitrifiable earths.

Acid of vitriol combined with vitrifiable earth.

Acid of vitriol combined with calcareous earth.

Natural hiſtory of plaſter-ſtone, alabaſter, gypſum, ſelenites.

Specimens of plaſter-ſtone from *Montmartre* near *Paris*, from *Cornwall*, *Derbyſhire*, *Weſtmoreland*, &c.

Specimens of rhomboidal ſelenites from *Shotover Hill* in *Oxfordſhire*, of ſtriated

ſtriated gypſum from *Derbyſhire*, of *gypſum phoſphoreſcens* from *Bononia*, &c.

Gypſeous earth analyſed by boiling it with ſalt of tartar·····Vitriolated tartar and calcareous earth obtained therefrom.

Hiſtory of the diſcovery of the *Bononian phoſphorus* ····· Experiments therewith.

Artificial Bononian phoſphorus made from calcined oyſter ſhells and flowers of ſulphur after Mr. *Canton*'s method·····Account of his experiments therewith.

Of the Combination of the vitriolic Acid with Phlogiſton, Spirits of Wine, and Oils.

Acid of vitriol combined with phlogiſton·····Sulphur.

Natural

Natural hiſtory of ſulphur.

Sulphur nativum, pellucidum & *opacum*, from *Solfatara* near *Naples.*

Sulphur nativum pulverulentum aquis efflorefcens, from the baths of *Aix-la-Chapelle.*

Account of the different methods of preparing crude ſulphur in *Germany, Saxony,* &c.

Sulphur purified by ſublimation -----Flowers of ſulphur-----Sulphur flag.

Sulphur cryſtallized.

Spirit of ſulphur *per campanam*----- Various ways of obtaining it.

Acid of vitriol changed into a volatile ſulphureous acid, by the addition of phlogiſton in a ſtate of diſſipation.

Volatile ſulphureous acid combined with the fixed alkaline ſalt of tartar-----*Stahl*'s ſulphureous ſalt.

Sulphureous ſalt of Stahl changed into

into vitriolated tartar by ſimple expoſure to the air, or by the addition of oil of vitriol.

Sulphur united with fixed alkaline ſalt by fuſion—*Hepar ſulphuris.*

Hepar ſulphuris changed into vitriolated tartar by the diſſipation of the phlogiſton—Analyſis of ſulphur.

Vitriolated tartar changed into hepar ſulphuris by the addition of phlogiſton—Syntheſis of ſulphur.

The proportion of the conſtituent parts of ſulphur deduced from the two preceding experiments of Stahl.

Hepar ſulphuris digeſted in rectified ſpirits of wine—*Tinctura ſulphuris.*

Sulphur rendered ſoluble in water, by boiling it with fixed alkaline *lixivia*, or with lime-water.

Sulphur precipitated from the preceding ſolutions by weak ſpirits of

of vitriol—*Lac ſulphuris*—*Sulphur præcipitatum.*

Sulphur united with volatile alkaline ſpirits by diſtilling it with ſal ammoniac and lime—*Tinctura ſulphuris volatilis.*

Action of water and acids upon ſulphur examined.

Remarks upon *M. le Comte de Lauragais'* Method of uniting Sulphur with Spirits of Wine.

Sulphur diſſolved in oil of turpentine—*Balſamum ſulphuris terebinthinatum.*

Sulphur diſſolved in oil of olives—*Balſamum ſulphuris ſimplex.*

Hiſtory of the Diſcovery of *Homberg's pyrophorus.*

Various pyrophori made from alum, Glauber's ſalt, &c. calcined in conjunction with matters containing phlogiſton.

Oil

Oil of vitriol mixed with rectified ſpirits of wine----Phænomena attending the commixtion----The mixture diſtilled----Æther of *Frobenius*—Sulphureous acid----Oil of ſpirits of wine ----Artificial reſin----Sulphur----Caput mortuum.

Specific gravity of æther determined.

Cold produced by the evaporation of æther----Of ſpirits of wine---- Of alkaline ſalts, &c.

Application of this principle of producing cold by evaporation, to the cooling of liquors, &c. in hot climates.

Phænomena attending the combuſtion of æther.

Miſcibility of æther with water, in certain proportions, proved.

The characteriſtics of æther, as

 diſ-

diſtinguiſhed from ſpirits of wine, and from eſſential oils.

Oil of vitriol mixed with oil of turpentine----Artificial reſin reſulting therefrom: Proportions of the ingredients which, cæteris paribus, produce the moſt ſolid reſin.

The preceding artificial reſin diſtilled — Sulphureous acid — Oil— Sulphur—Caput mortuum.

Of Nitre.

Account of the different methods of making nitre in the Eaſt-Indies, and in Europe.

Of the medium quantity of nitre annually imported into Great Britain from the Eaſt-Indies, and exported to various parts of Europe.

Crude nitre extracted from nitrous earths.

Crude East-India nitre purified from sea salt, and calcareous earth.

Nitre from America.

Account of the attempts to make nitre in England.

Analysis of the mother water of nitre.

History of the medicinal application of *magnesia alba.*

Nitre analyzed by distilling it with calcined vitriol—Acid of nitre or *aqua fortis*—Residuum.

Residuum of the preceding process analyzed—Vitriolated tartar—Ferrugineous earth.

Acid of nitre procured by distilling nitre with sand, clay, alum, &c.

Fuming acid of nitre procured by distilling nitre with oil of vitriol:—Residuum examined.

Fuming acid of nitre purified by dis-

diſtilling it with nitre. Teſt of the purity of acid of nitre.

Fuming acid of nitre mixed with water----Change of colour obſerved ----Degree of heat aſcertained.

Fuming acid of nitre mixed with ſnow, and with powdered ice----Degree of cold aſcertained.

Fuming acid of nitre mixed with the cryſtals of kelp—Degree of heat obſerved.

Diluted acid of nitre mixed with cryſtals of kelp----Degree of cold obſerved.

Fuming acid of nitre ſimple, and combined with oil of vitriol mixed with various oils—Inflammation produced thereby—Reſidua.

Enumeration of the various oils which have been obſerved to take fire, to effervefce without taking fire, and which neither effervefce or

take fire, when mixed with the fuming acid of nitre.

Acid of nitre dulcified with rectified ſpirits of wine, by diſtillation and digeſtion.

Nitrous æther made by ſpontaneous diſtillation, and by digeſtion.

Nitre alkalized by fuſion.

Nitre alkalized by charcoal—*Clyſſus* of nitre.

Volatile alkali in a concrete form ſeparated from the *clyſſus* of nitre.

Nitre detonated with tartar in various proportions—White flux—Black flux.

Nitre deflagrated with ſulphur—*Sal polychreſtus*—*Sal prunellæ*.

Pulvis fulminans made from nitre, ſalt of tartar and ſulphur—Exploſion of pulvis fulminans.

Hiſtory of the invention of gunpowder.

Gunpowder made from nitre, sulphur, and charcoal----Account of the different proportions of the ingredients used in different countries, and in different works in England—Best proportions ascertained.

Method of extracting nitre from damaged gunpowder at Woolwich, &c.

Gunpowder decomposed-----The three constituent parts exhibited separate—Method of detecting frauds used in the composition of gunpowder explained.

Acid of nitre combined with calcareous earth—Calcareous nitre—*Phosphorus Balduini.*

Acid of nitre combined with argillaceous earth—Aluminous nitre.

Acid of nitre combined with the vegetable fixed alkali—Regenerated nitre.

Acid

Acid of nitre combined with the mineral fixed alkali—Quadrangular or cubic nitre.

Acid of nitre combined with volatile alkali—Nitrous ſal ammoniac.

Of the uſe of nitre in agriculture.

The uſe of ſnow in fertilizing the ground, ſhewn not to depend upon the nitre it is generally ſuppoſed to contain.

Of Sea Salt.

Natural hiſtory of ſea ſalt—*Sal marinus*, *fontanus*, *foſſilis*.

Hiſtory of the diſcovery of foſſil ſalt in England.

Account of the method of preparing ſea ſalt in different parts of the world.

Of the different antiſeptic powers of

of ſea ſalt according to the different proceſſes by which it is prepared.

Of the bittern of ſea ſalt.

Of the method by which Epſom ſalts, common Glauber's ſalts, and magneſia, are extracted from the bittern of ſea ſalt at Lymington, and other places.

Method of diſtinguiſhing the genuine ſal mirabilis Glauberi from the counterfeit of the ſhops.

Analyſis of ſea water, attempted.

Comte *Marſigli*'s artificial ſea water.

M. de Francheville's opinion, concerning the ſaltneſs of the ſea, examined.

Mr. *Boyle*'s opinion, concerning the uniform ſaltneſs of the ſea at different depths, examined.

Account of various attempts to edulcorate ſea water.

Of

Of Mr. *Irving*'s late attempt.

Of the tefts of the purity of diftilled fea water.

Of the phofphoric quality of fea-water in particular places, and at particular times in the fame place.

Mr. *Canton*'s experiments concerning the caufe of the luminoufnefs of fea water.

Account of other opinions concerning the fame fubject.

Sea falt diffolved and cryftallized.

Decrepitation and fufion of fea falt.

Sea falt analyzed by diftilling it with acid of vitriol after Glauber's manner—Fuming fpirit of falt—Refiduum.

The refiduum of the preceding procefs analyzed, and the fixed alkaline bafis of fea falt obtained therefrom after Marggraf's method.

Glauber's

Glauber's fuming ſpirit of ſalt purified by diſtilling it with ſea ſalt.

Sea ſalt diſtilled with vitriol, clay, &c.—Acid of ſea ſalt.—Reſidua.

Acid of ſea ſalt ſeparated from its alkaline baſis by acid of nitre.

Acid of ſea ſalt combined with calcareous earth—*Phoſphorus Hombergi.*

Acid of ſea ſalt combined with argillaceous earth—Muriatic alum.

Acid of ſea ſalt combined with earth of *ſal catharticus amarus.*

Acid of ſea ſalt combined with fixed alkali of tartar—*Sal febrifugus Sylvii.*

Acid of ſea ſalt combined with alkali of kelp—Sea ſalt regenerated.

Acid of ſea ſalt combined with volatile alkali—Artificial ſal ammoniac.

Acid of ſea ſalt dulcified by diſtillation with ſpirits of wine.

Marine æther made after the *Marquis de Courtanvaux*'s manner.

Aqua regia made by mixing together acid of ſea ſalt and acid of nitre.

Aqua regia made by diſſolving ſea ſalt or ſal ammoniac in acid of nitre —Its difference from the preceding aqua regia, remarked.

Of ſea ſalt as a condiment, and as a manure.

Of Sal Ammoniac.

Natural hiſtory of ſal ammoniac.

Method of making ſal ammoniac in *Egypt*.

Method of making ſal ammoniac in *Europe*.

Sal ammoniacus gleboſus from Solfaterra.

Sal ammoniac purified by ſublimation.

Sal ammoniac purified by cryſtallization.

Sal ammoniac diſſolved in ſpirits of wine.

Sal ammoniac deflagrated with nitre.

Sal ammoniac analyſed by diſtilling it with the acid of vitriol, and of nitre—Marine acid—Reſidua.

Sal ammoniac analyſed by diſtilling it with fixed alkali—Volatile alkali—Reſiduum.

The volatile alkaline ſpirit of ſal ammoniac procured by diſtilling it with quicklime—Cauſtic ſpirit of ſal ammoniac.

The reſiduum of the proceſs examined—*Oleum calcis.*

Volatile alkaline ſalt ſpirit procured

cured by diſtilling ſal ammoniac with chalk—Mild ſpirit.

Cauſtic ſpirit of ſal ammoniac mixed with acids, with ſpirits of wine, lime-water, calcareous nitre, &c.

Mild ſpirit of ſal ammoniac mixed with acids, with ſpirits of wine, lime-water, calcareous nitre, &c.

Eau de luce made.

Degree of cold, produced during the ſolution of ſal ammoniac in water, obſerved by a thermometer.

Equal quantities of water of different temperatures ſaturated with ſal ammoniac, and the degrees of cold ſeverally produced during the ſaturation remarked.

Of the greateſt poſſible degree of cold which can be produced in water by the ſolution of ſal ammoniac.

Of the uſe of ſal ammoniac in various arts.

Of Borax.

Natural hiſtory of *tincal*, or crude borax.

Borax vitrified.

Glaſs of borax diſſolved in water, and cryſtallized.

Sal ſedativus Hombergi ſeparated from borax by the acids of vitriol, nitre, ſea ſalt, and vinegar, and procured by ſublimation and cryſtallization.

The reſidua examined, and the mineral fixed alkali ſeparated therefrom.

Borax regenerated by combining together ſal ſedative and mineral alkali.

Sal ſedative diſſolved in ſpirits of

wine, the green colour of the flame observed.

Of copper ſuppoſed to be contained in borax.

Account of the attempts to make artificial borax in *England*.

Of the mechanic uſes of borax.

Of Mineral Earths, crude and calcined.

Diſtillation of ſiliceous, calcareous, argillaceous, and gypſeous earths.

Account of the experiments lately made at *Paris*, by M. *Darcet*, and others, concerning the infuſibility and volatility of diamonds in a great degree of heat.

Vitrification of a mixture of earths, ſeparately unvitrifiable in a given degree of heat.

Glaſs made from a mixture of alkaline ſalts and powdered flints.

History of the invention of glaſs.

Of the method of making and poliſhing plate glaſs in France, &c.

Siliceous earths rendered ſoluble in water by means of alkalis—*Liquor ſilicum.*

Of European and Aſiatic porcelain, and their ſpecific difference.

Account of the methods of making the white and yellow Staffordſhire ware.

Calcareous earths converted into lime by calcination.

Calcareous earths converted into lime by ſolution and precipitation.

Lime converted into calcareous earth.

Dr. *Black*'s theory of lime explained.

The quantity of fixed air contained in alkalis, and calcareous earths, and ſeparable by ſolution, eſtimated

estimated by the Honourable *Hen. Cavendish*.

The loss of weight sustained by calcareous earths during calcination estimated by experiment, and shewn to correspond with the quantity of fixed air, separated therefrom by solution.

Of the solubility of lime in water.

Of the pellicle of lime-water, and of the excess of its weight above the weight of the lime dissolved.

Is the smallest quantity of lime wholly soluble in the largest quantity of water, without undergoing a fresh calcination?

Of marle.

Of the use of lime, marle, &c. in agriculture.

Of Arsenic.

Natural history of white pyrites,

 orpiment,

orpiment, realgar, cobalt ores, and other mineral fubftances affording arfenic.

Method of procuring arfenic in *Saxony*, called from its powdery appearance, *farina arfenicalis*.

Farina arfenicalis purified, and changed into white cryftalline arfenic, by being mixed with pot-afh and fublimed.

Farina arfenicalis mixed with the fulphur of fulphureous pyrites, and changed into yellow or red cryftalline arfenic by fublimation.

Arfenic diffolved in oil of olives, in oil of turpentine, in a folution of fixed alkali, in rectified fpirits of wine, in aqua fortis, in acid of fea-falt, in aqua regia, in oil of vitriol, in vinegar, and in water.

Arfenic and nitre diftilled together—Acid of nitre—Refiduum.

Macquer's

Macquer's neutral arſenical ſalt extracted from the reſiduum.

Nitre and arſenic fuſed together in open veſſels—Fume—Reſiduum called nitre fixed by arſenic.

Arſenic combined with phlogiſton, and ſublimed into a metallic appearance, commonly called *regulus* of arſenic.

OF METALLIC SUBSTANCES IN GENERAL.

Of Mercury in a fluid State.

Natural hiſtory of mercury and of cinnabar.

Mercury extracted from earths or ſtones with which it is mixed, by ſimple lotion, and by diſtillation without addition.

Mercury extracted from minerals,

in which it is mineralized, by distillation with addition.

Method of assaying mercurial minerals, and of discovering whether any particular mineral contains mercury.

Methods of purifying mecury.

Mercury changed into a black powder by long continued trituration.

Mercury changed into a red powder by calcination—*Mercurius calcinatus*—*Mercurius præcipitatus per se*.

Mercury boiled with water.

Mercury revivified, from the powders obtained by trituration, and calcination, by simple distillation.

Account of *Boerhaave*'s experiments relative to the unchangeableness of mercury, by the processes of digestion and distillation.

Account

Account of Professor *Braunius*'s experiments, relative to the conversion of mercury into a solid malleable metal, at *Petersburgh*, by an artificial cold resulting from the solution of snow in the fuming spirit of nitre.

Of the degree of heat of boiling mercury, and of the limits within which mercury may be used as a thermometer.

Mercury triturated with turpentine, with lard, with sugar, &c.—Mercurial plasters, ointments, pills.

Mercury dissolved in acid of nitre—The solution diluted with distilled water, *aqua mercurialis*.

The solution of mercury in acid of nitre crystallized.

The same inspissated—*Calx mercurii*.

The inspissated mass, or crystal-

lized ſalt, calcined to a red colour—*Mercurius præcipitatus ruber.*

Mercurius præcipitatus ruber dulcified by ſpirit of wine—*Mercurius corallinus—Arcanum corrallinum.*

Mercury precipitated from its ſolution in acid of nitre by copper.

Mercury corroded into a ſaline maſs by oil of vitriol.

The preceding ſaline maſs partly diſſolved, principally changed into an inſipid, indiſſoluble, yellow powder, by frequent ablution in warm water—*Mercurius emeticus flavus—Mercurii præcipitatum flavum—Turpethum minerale.*

Mercury precipitated, from the waſhings of turpeth mineral; by alkalis.

Waſhings of turpeth mineral inſpiſſated, and deliquiated—*Oleum mercurii.*

Mercury united by ſublimation with the acid of ſea ſalt; corroſive ſublimate made from a mixture of unwaſhed turpeth mineral and ſea ſalt.

Corroſive ſublimate made from cryſtals of mercury in the nitrous acid and ſea ſalt.

Corroſive ſublimate made from crude mercury, nitre, calcined vitriol, and ſea ſalt.

Corroſive ſublimate rendered mild and inſipid, by trituration with a ſufficient quantity of crude mercury and ſubſequent ſublimations—*Mercurius dulcis ſublimatus*—*Calcmelas*—*Aquila alba*—*Panacæa mercurialis*—*Draco mitigatus*, &c.

Specific gravities of corroſive ſublimate and calomel, determined.

Corroſive ſublimate diſſolved in water, and cryſtallized.

Corroſive

Corrosive sublimate dissolved in spirits of wine.

Mercury precipitated from a solution of corrosive sublimate in water by fixed alkalis----*Mercurius præcipitatus fuscus*, by volatile alkali—*Mercurius præcipitatus dulcis*, by lime water—*Aqua phagedenica*.

Mercury precipitated from its solution in acid of nitre by the acid of sea salt, or by any neutral salt containing the acid of sea salt.—*Mercurius præcipitatus albus*.

Mercury precipitated from its solution in acid of nitre by the acid of vitriol, or any neutral salt containing the acid of vitriol—Turpeth mineral.

Mercury dissolved in the vegetable acids, native, and fermented, and in fixed, and volatile alkalis, after *Marggraf's* method.

Account

Account of *M. le Comte de la Garaye*'s tincture of mercury in ſpirits of wine.

Mercury united with ſulphur by trituration, and by fuſion—*Æthiops* mineral.

A mixture of ſulphur and mercury ſublimed—Factitious cinnabar.

Factitious cinnabar levigated—*Vermillion*.

Method of diſcovering whether vermillion be adulterated with red lead.

Mercury revivified by diſtilling cinnabar with iron-filings.

Mercury united with volatile tincture of ſulphur, and with hepar ſulphuris.

OF SEMIMETALS.

Of Antimony, and Regulus of Antimony.

Natural hiſtory of antimony, and other ores of *regulus* of antimony.

Crude

Crude antimony ſeparated from earthy and ſtony impurities by eliquation, or diſtillation per deſcenſum —*Morſuli reſtaurantes Kunckelii.*

Crude antimony digeſted with aqua regia, ſolution of the metallic, and ſeparation of the ſulphureous part effected thereby.

Crude antimony calcined to an aſh-coloured calx.

Calcined antimony vitrified.

Glaſs of antimony digeſted with aqua regia, ſulphur ſometimes ſeparated thereby—Differences obſervable in the fuſibility, colour, pellucidity, and ſolubility of glaſs of antimony in wines, and other menſtruums, according to the different degrees of calcination uſed in preparing it.

Regulus of antimony prepared, by fuſing the calx, or glaſs of antimony with

with charcoal, ſoap, or other phlogiſtic matters.

Regulus of antimony prepared, by fuſing crude antimony with iron, with lead, with copper, &c.

Regulus of antimony prepared, by fuſing crude antimony with tartar and nitre.

Chief mechanic uſes of regulus of antimony noticed.

Regulus of antimony volatilized by a ſtrong fire—Flowers of regulus of antimony.

Method of reducing flowers of regulus of antimony.

Action of acids upon regulus of antimony, examined.

Regulus of antimony combined with the marine acid by diſtilling antimony and corroſive ſublimate together—*Cauſticum antimoniale*, or butter of antimony.

Regulus

Regulus of antimony precipitated from the marine acid, by diluting butter of antimony with water—*Pulvis algaroth*—*Mercurius vitæ*.

Regulus of antimony precipitated from the water used in the preceding process, commonly called *spiritus vitrioli philosophicus*, by an alkali.

Bezoard mineral prepared, by repeated abstractions of the acid of nitre from butter of antimony—*Spiritus bezoardicus*.

Antimony and nitre mixed together in the proportion of 2 to 1, and deflagrated—*Crocus antimonii mitior*.

Antimony and nitre mixed together in equal parts, and deflagrated—*Crocus antimonii*—*Hepar antimonii*, edulcorated—*Crocus metallorum*.

Antimony and nitre mixed together in the proportion of 1 to 2, deflagrated and edulcorated—*Emiticum mite antimonii*.

Antimony

Antimony and nitre mixed together in the proportion of 1 to 3, deflagrated and edulcorated—*Calx antimonii*—*Antimonium diaphoreticum dulce*.

Different chemical properties of the preceding, and other similar combinations of nitre and antimony, explained; general account of their medical powers deduced therefrom.

Washings of diaphoretic antimony considered — *Materia perlata*, or *Boerhaave's sulphur fixatum stibii* precipitated therefrom.

Regulus of antimony reduced to calx, similar to diaphoretic antimony, by deflagration with nitre, called *ceruse of antimony*.

Antimony combined with fixed alkali by boiling them together.— —*Kermes* mineral spontaneously precipitated from the solution.

Tinctura antimonii made by digesting hepar antimonii in spirits of wine.

Vinum

Vinum antimoniale sive emeticum, made by digesting crocus antimonii, or glass of antimony, in mountain wine.

Tartarus emeticus made by boiling glass, or crocus of antimony, with cream of tartar.

Tartarus emeticus made, after *Macquer*'s manner, by combining pulvis algaroth and cream of tartar.

Of the medical virtues of antimonial preparations in general, and the cause of the variable and uncertain effects of particular preparations explained.

Of Zaffre and Regulus of Cobalt.

Method of making *zaffre* in Saxony.

The zaffre of the shops dissolved in all the mineral acids.

The difference of the colour of

the ſolution of zaffre in weak and ſtrong acid of ſea ſalt obſerved.

The *tawny* colour of zaffre diſſolved in weak ſpirit of ſalt, changed into a *green* by heating the ſolution.

Zaffre changed into a blue glaſs by vitrification, called *ſmalt*.

Method of preparing from the blue glaſs of zaffre, an impalpable powder, called in that ſtate *azure*, *enamel blue*, *powder blue*.

Of *lapis lazuli*, and the pigment called *ultramarine blue* prepared therefrom, and its difference from the azure prepared from zaffre.

Regulus of cobalt procured from zaffre or ſmalts, when melted in conjunction with matters containing phlogiſton.

General properties of regulus of cobalt enumerated.

 Account

Account of the manufacturing of ſmalts in England.

Orpiment and quicklime digeſted together with water — *Liquor vini probatorius.*

Uſe of the preceding liquor in detecting adulterations of wine by *ſaccharum Saturni*, ſhewn from the different colours of the precipitates attending its mixture with genuine and adulterated wine.

Experiments with the aforeſaid liquor as a ſympathetic ink.

Of Nickel.

Nickel not ſoluble in acid of vitriol, with difficulty in acid of ſea ſalt, readily by acid of nitre into a green colour.

Nickel precipitated from acid of nitre by a fixed alkali into a greeniſh powder.

Nickel

Nickel compared with regulus of cobalt.

Experiments with ſympathetic inks from ſolutions of nickel and cobalt.

Of Biſmuth.

Natural hiſtory of biſmuth.

Biſmuth ſublimed into yellowiſh flowers by a ſtrong fire.

Biſmuth changed into an aſh-coloured powder by calcination.

Calx of Biſmuth vitrified.

Vitrified calx of biſmuth reduced by the addition of phlogiſton.

Biſmuth diſſolved in acid of nitre.

Solution of biſmuth in acid of nitre cryſtallized.

Biſmuth precipitated from the ſolution in acid of nitre by the affuſion of water — *Magiſtery of Biſmuth— Blanc de fard.*

Biſmuth precipitated from the

washings of the magistery by a fixed alkali.

Bismuth and mercury melted together—Amalgam.

Bismuth, lead, and mercury, melted together — Method of falsifying quicksilver — Method of detecting the adulteration of quicksilver.

Bismuth not miscible by fusion with nickel.

Of Zinc.

Natural history of *lapis calaminaris, black jack*, and other ores of zinc.

Zinc procured by distilling lapis calaminaris with charcoal.

Account of the method of making English zinc at the copper works near Bristol, and its difference from Indian zinc shewn.

Zinc calcined in a gentle fire, inflamed in a strong fire—Flowers of

of zinc, or *lana philoſophorum* ſeparated during the combuſtion of zinc.

Flowers of zinc vitrified.

Flowers of zinc reduced in cloſe veſſels.

Flowers of zinc diſſolved in all the acids.

Zinc deflagrated with nitre.

Zinc diſſolved in acid of vitriol —Nature of the black *flocculi* ſeparated during the ſolution.

Solution of zinc in acid of vitriol cryſtallized—white vitriol.

Method of diſcovering whether white vitriol contains copper.

Difference between Engliſh and *Goſlarian* white vitriol.

Zinc diſſolved in acid of nitre.

Solution of zinc in acid of nitre cryſtallized.

Zinc diſſolved in the concentrated acid of ſea ſalt, and in the aqueous acid

acid of vitriol—Inflammable air separated during the solution in each menstruum.

The quantity, and specific gravity of the inflammable air separated from zinc by solution, estimated by the Hon. *Henry Cavendish*.

Zinc not acted upon by sulphur, or liver of sulphur—Purified thereby from all other metallic substances.

Zinc not miscible by fusion with bismuth.

OF METALS.

Of Lead.

Natural history of lead ores.

Account of the two different methods of extracting lead from its ore, as practised in Derbyshire.

Lead extracted from its ore—Method of assaying simple lead ores.

Lead in fusion partly volatilized,

chiefly

chiefly converted into a gray calx, called *plumbum uſtum*, or calcined lead.

Plumbum uſtum melted in a ſtrong fire—*Litharge*.

Account of the method of making red lead from plumbum uſtum, as practiſed in Derbyſhire.

Account of the method of making red lead from litharge, as practiſed in Flintſhire.

Remarks concerning the quantity, and cauſe of the increaſe of weight, gained by the converſion of lead into minium.

Glaſſes of lead made from minium ſimple, and mixed with vitrifiable earth in different proportions.

Artificial ores, perfectly reſembling ſome kinds of natural ores of lead, made from an union of lead and ſulphur.

Of *black lead* or *wadd.*

Method of diſtinguiſhing the factitious from the true black lead.

Black lead expoſed to a ſtrong fire in cloſe veſſels—Fixity remarked.

Black lead expoſed to a ſtrong fire in open veſſels—Loſs of weight remarked.

Calcined black lead attracted by the magnet.

Lead corroded into a white calx by the vapour of vinegar, called *ceruſſe*, or white lead.

Account of the method of manufacturing white lead at Holywell, and other places, and of the increaſe of weight gained by the lead.

White lead, minium, or litharge, diſſolved in diſtilled vinegar, and cryſtallized—*Sugar of lead.*

Crude lead, white lead, minium, or

or litharge diffolved in oil of olives —Common *diachylon* plafter.

Method of difcovering whether oil of olives be adulterated, by means of lead, with rape-feed, or other expreffed oils.

Lead feparated, from its folution in oils, by vinegar.

Lead diffolved in acid of nitre, and cryftallized.

Lead precipitated from acid of nitre by acid of vitriol, or any neutral falt containing acid of vitriol; by acid of fea falt, or any neutral falt containing acid of fea falt.

Lead diftilled to drynefs with oil of vitriol —Sulphureous acid— Sulphur—Saline refiduum.

Sulphur procured inftantaneoufly by pouring oil of vitriol upon lead in fufion, and collecting the vapour.

Lead or minium diftilled with fal ammoniac

ammoniac — Volatile alkaline spirit —Volatile alkaline salt—Residuum, or a combination of the acid of sea salt with lead, called *plumbum corneum*.

Plumbum corneum fused.

Plumbum corneum dissolved in water, and crystallized.

Lead and mercury melted together in different proportions—Amalgams of various consistencies.

Of Copper.

Natural history of copper.

Account of the processes used in extracting copper from its ore, at Ecton, Macclesfield, Cheadle, &c.

Regulus and *scoria* of the first, second, third, and fourth fusion of copper ore examined, and the reason of their differences explained.

Copper

Copper combined with ſulphur by ſtratification and cementation—*Æs uſtum.*

Copper combined with ſulphur by fuſion—Artificial ore of copper.

Copper combined with arſenic by fuſion—*White copper.*

Of Chineſe white copper, improperly called *tutenag*, and its difference from the preceding white copper ſhewn.

Copper changed into *braſs*, by cementing and fuſing copper in conjunction with calcined calamine and charcoal.

Copper changed into braſs, by ſubſtituting, in the preceding proceſs, calcined black jack for calamine.

Braſs changed into copper, by diſſipating the zinc or metallic part of the calamine, in a ſtrong fire.

The

The increaſe of weight, gained by the copper in being changed into braſs, eſtimated.

Copper melted with zinc—*Pinchbeck.*

Difference between pinchbeck and braſs obſerved, and the reaſon explained.

Copper melted with tin in various proportions — *Bell metal* — *Bronze*, &c.

Equal parts of copper and tin melted together; their mutual penetration and increaſe of ſpecific gravity obſerved.

Copper diſſolved in oil of vitriol.

Solution of copper in oil of vitriol cryſtallized—*Blue vitriol.*

Copper precipitated from a ſolution of blue vitriol by iron—*Cuprum præcipitatum*, called *ziment copper.*

Account of the cement or ziment waters

waters at Newsol in Hungary, Arklow in Ireland, in Anglesea, &c. and of the methods of procuring copper from them.

Copper dissolved in acid of nitre, and crystallized.

Copper precipitated from acid of nitre by chalk—*Verditer blue.*

Copper dissolved in acid of sea salt, and crystallized.

Crystals of copper, in the acids of sea salt and nitre, when dissolved in spirits of wine, communicate a green colour to the flame.

Copper dissolved in oils, in vegetable acids, in fixed and volatile alkalis, in neutral salts, &c.

Account of the method of making *verdigrise* at Montpellier, and in England.

Various mechanical applications of verdigrise enumerated.

Verdigrise dissolved, in part, in distilled vinegar.

Solution of verdigrise in distilled vinegar crystallized, improperly called *viride æris distillatum*.

Crystals of verdigrise distilled.... Concentrated acid of vinegar, called *acetum radicatum* — Cupreous residuum.

Acetum radicatum mixed with rectified spirits of wine, and acetous æther made after the manner of *M. le Comte de Lauragais*.

Of Iron.

Natural history of iron.

Account of the processes used in extracting iron from its ores in different parts of England and Wales; and of the attempts to make pig iron by coke and charred peat.

Method

iron during the two preceding solutions collected and inflamed.

Of fulminating damps in mines.

Method of freeing the coal-pits at Whitehaven from inflammable air described.

Iron dissolved in acid of nitre, elastic but not an inflammable air produced thereby.

History of the discovery of the method of making *Prussian-blue.*

Prussian blue made by precipitating a solution of green vitriol with an alkali saturated with phlogiston.

The colouring matter of Prussian blue extracted by an alkali.

Iron precipitated from any of its acid solvents into a blue powder by a fixed alkali, saturated with the colouring matter of Prussian blue.

Iron precipitated from any of its acid solvents into a black powder by

by a decoction of galls or other aſtringent vegetables.

Nature of ink and of the black dye, and the difference between them explained.

Beccher's experimentum ferriferum conſidered.

Iron ſhewn to exiſt in common ſand, in coloured clays, in the aſhes of vegetables, in the aſhes obtained from the blood, urine, and fleſh of animals.

Vegetable aſhes melted into a green or blue glaſs, according to the violence of the fire.

Iron filings or colcothar of vitriol mixed with ſal ammoniac and ſublimed—*Elores martiales*—Reſiduum.

Reſiduum deliquiated—*Lixivium Martis*—*Oleum ferri.*

Flowers of iron digeſted with ſpi-

rits of wine—*Tinctura florum martialium.*

Iron precipitated from its ſolution in acid of nitre by fixed alkali—*Stahl*'s alkaline tincture of iron.

Iron combined with cream of tartar by grinding them together—*Rotuli martiales—Mars ſolubilis* ; by boiling, *tartarus chalybeatus*, *tinctura ſtyptica Helvetii.*

Iron diſſolved in Rheniſh wine—*Vinum chalybeatum.*

Of Tin.

Natural Hiſtory of tin.

Of the proceſſes of ſtamping, buddling, and trunking uſed in *Cornwall* for preparing tin ore for fuſion.

Of the *magnetrien* uſed in ſome parts of Germany.

Tin melted and granulated.

Tin rendered hard and ſonorous by

by being melted in conjunction with regulus of antimony, with zinc, with bismuth, &c.

Of *pewter* and its different kinds.

Of different metallic mixtures which melting with less heat than the metals to which they are applied, constitute solders of various kinds.

Method of manufacturing *tin plates* in England and Germany, and of tinning copper vessels.

Tin calcined singly and in conjunction with lead—*Putty*.

Calces of lead and tin melted with calcined flints, or other vitrifiable earths, and alkaline salts, in various proportions·····*white enamels*.

White enamels converted into different colours, by the addition of metallic calces, and applied upon English and Indian porcelain.

Pastes and artificial precious stones

 made,

made, and their difference from coloured enamels explained.

Tin amalgamated with quickfilver, and the amalgam mixed with fulphur and fal ammoniac, and fublimed----Refiduum called *aurum mofaicum or mufium*.

Tin diffolved in aqua regia-----Different confiftences of the folutions.

Tin diffolved in acid of nitre.

Ufe of the preceding folutions of tin in precipitating the colouring matter of cochineal.

Woollen and linen boiled in cochineal precipitated by tin-----Reafon of the different dyes explained by *Macquer*.

Inflammable air feparated from tin during its folution in acid of vitriol and acid of fea falt.

Account of *Marggraf*'s experiments upon the folubility of tin in vegetable

vegetable acids, native and fermented.

Tin amalgamated with quicksilver, and the amalgam diſtilled with corroſive ſublimate---- *Liquor fumans Libavii*-----Butter of tin-----Revivified mercury.

Looking glaſs ſilvered by amalgamating mercury and tin.

Tin, biſmuth, and lead melted together, and mixed with mercury----- Method of ſilvering concave glaſs veſſels with the mixture.

Of Silver.

Natural hiſtory of ſilver.

Account of the method of ſeparating native ſilver from the ſtones or earths in which it is imbedded, by amalgamation with mercury; as practiſed at *Potoſi* and other Spaniſh

ſilver mines in America, and at *Kungsburg* in Norway.

Account of the method of ſeparating ſilver when mineralized with ſulphurated lead, as practiſed in Flintſhire, and in Northumberland.

Cardiganſhire lead ores aſſayed for ſilver.

Silver purified from ſemimetals, and imperfect metals, by cupellation with lead.

Silver purified from ſuch minute portions of copper as eſcape cupellation, by fuſion with nitre and borax.

Silver ſeparated from $\frac{1}{3}$, or any leſs part of its weight of gold by ſolution in acid of nitre----Quartation or departure.

Silver recovered from its ſolution in acid of nitre by precipitation with copper.

Solution

Solution of ſilver in acid of nitre cryſtalized.

Cryſtals of ſilver melted—*Lunar cauſtic.*

Silver precipitated from acid of nitre, by acid of vitriol, or by any neutral ſalt containing acid of vitriol.

Silver diſtilled to dryneſs with acid of vitriol—Sulphureous acid—Saline reſiduum.

Saline reſiduum diſſolved in water, and cryſtallized.

Silver precipitated from acid of nitre, by acid of ſea ſalt, or by any neutral ſalt containing it····*Lunar cornea.*

Marggraf's method of obtaining ſilver abſolutely pure by the reduction of luna cornea.

Silver precipitated from its ſolution in acid of nitre by fixed alkali.

Precipitated ſilver diſſolved in vegetable acids, in volatile, and phlogiſticated fixed alkalis, according to *Marggraf*'s method.

Pure ſilver made harder by being melted with copper in the proportion of 37 to 3·····*Standard ſilver of England*.

Silver precipitated from acid of nitre, largely diluted with water, by means of mercury·····*Arbor Dianæ*.

Silver combined with ſulphur into an artificial ore reſembling the *minera argenti vitrea*.

Of Gold.

Natural hiſtory of gold.

Method of ſeparating native gold from ſands, earths, &c. by amalgamation with quickſilver.

Method of extracting gold when mineralized, or when ſo mixed with ſulphur

ſulphur by means of other metals as to eſcape the action of quickſilver and aqua regia.

Gold ſoluble in aqua regia, but not in acid of nitre.

Silver ſoluble in acid of nitre, but not in aqua regia.

Method of purifying gold from all metallic ſubſtances by ſolution in aqua regia, and precipitation with green vitriol.

Method of ſeparating a minute portion of gold from a large quantity of ſilver, by melting the mixture with ſulphur, as practiſed at Rammelſberg.

Gold precipitated from its ſolution in aqua regia made with acid of nitre and acid of ſea ſalt, by volatile alkali—*Aurum fulminans.*

Aurum fulminans deprived of its fulminative power by oil of vitriol, by

by fusion with sulphur, by fixed alkali, and in part by ablution with water.

Gold precipitated from its solution in aqua regia, when largely diluted with water, by plates of tin, or by solution of tin in the same menstruum — *Purple magistery of Cassius.*

Glass changed into an artificial ruby by being melted with Cassius' purple magistery.

Gold extracted from its solution in aqua regia, and kept suspended in æther.

Method of separating gold from gilt copper.

Gold precipitated from its solution in aqua regia by fixed alkali.

Precipitated gold dissolved by the same menstruums as precipitated silver.

Gold diſtilled to dryneſs with the acid of vitriol, with the acid of ſea ſalt, and with the acid of nitre—Inſoluble in theſe menſtruums.

Gold diſſolved in hepar ſulphuris.

Pure gold hardened by being melted with copper, or with an admixture of copper and ſilver, in the proportion of 22 to 2—*Standard gold of England*.

Gold amalgamated with mercury—Methods of gilding and ſeparating gold from gilt works.

OF MINERAL WATERS IN GENERAL, AND THEIR VARIOUS IMPREGNATIONS.

Different methods of aſſaying mineral waters, and their imperfections.

Of *thermæ*, or hot mineral waters, and

and the different conjectures concerning the cause of the heat.

Account of Dr. *Brownrigg*'s experiments on the fixed air contained in *Spa* water.

M. *Lane*'s experiments concerning the suspension of iron in water, by means of fixed air discharged either from fermenting, or effervescing mixtures.

Of Bituminous Substances.

Natural history of bituminous substances.

Newcastle coal distilled----Phlegm ---- Acid---- Air----Oil----Caput mortuum.

Air discharged from Newcastle coal by distillation, collected, and shewn to be inflammable, and to retain its elasticity and inflammability for several days.

Peat

Peat from the iſle of *Ely* diſtilled —Phlegm—Acid—Oil—Alkali— Caput mortuum.

Amber diſſolved in ſpirits of wine.

Amber precipitated from its ſolution in ſpirits of wine by water.

Amber diſtilled—Phlegm—Acid ſpirit—Volatile acid ſalt—Oil— Caput mortuum.

Method of rectifying oil of amber.

Method of purifying ſalt of amber.

Amber varniſh made by different methods.

OF VEGETABLES.

Of vegetable juices ſpontaneouſly extravaſated, or exuding upon inciſion.

Of liquid Reſins or Balſams.

Venice turpentine diſtilled without addition with the heat of boiling water

water—Acidulated phlegm—Colourless aſſential oil, commonly called ætherial ſpirit of turpentine—*Reſinous reſiduum.*

The reſiduum of the preceding proceſs diſtilled with a degree of heat exceeding that of boiling water—Acid—Yellow oil—Reſiduum called *colophony.*

Colophony diſtilled to dryneſs—Acid—Reddiſh oil, called by ſome, balſam of turpentine—Caput mortuum.

Common turpentine diſtilled with water—Eſſential oil, vulgarly called ſpirit of turpentine—Reſiduum—*Terebinthina coɫta*, or common roſin.

Turpentine diſſolved in ſpirits of wine, and precipitated therefrom by water.

Of *tar* and *pitch*, and the method of procuring them.

Tar diſſolved in part in water.

Of lamp black, and the method of obtaining it.

Balſam of *capivi* diſtilled *balneo arenæ*—Acid—Yellow oil—Blue or green oil—Caput mortuum.

Of balſam of *Gilead*, balſam of *Peru*, balſam of *Tolu*, liquid amber, &c.

Of ſolid Reſins.

Benzoine diſſolved in ſpirits of wine, and precipitated therefrom by water—Virgin's milk.

Acid phlegm and eſſential ſalt, commonly called flowers of benzoine, obtained from benzoine by ſublimation.

Eſſential ſalt obtained from benzoine by elixation with water and cryſtallization.

Flowers

Flowers of benzoine dſſolved in water, and ſpirits of wine.

The reſiduum from the ſublimation of the flowers of benzoine diſtilled—Acid—Oil of different conſiſtences—Caput mortuum.

Elemi — Maſtic — Copal—Dragon's blood, and other ſolid reſins diſſolved in ſpirits of wine and oils.

Different kinds of varniſhes made, and applied upon wood and metals.

Of Camphor.

Native camphor.

Rough camphor refined by ſublimation.

Rough camphor refined by ſolution in ſpirits of wine.

Camphorated ſpirits of wine inflamed.

Camphor diſſolved in acid of nitre and in acid of vitriol.

Camphor

Camphor ſeparated from ſpirits of wine, and from mineral acids, by the addition of water.

Of Gums.

Gum arabic, gum tragacanth, gums from pear trees, plum trees, apricot trees, &c. diſſolved in water—Mucilages.

Gums diſſolved in water, and precipitated therefrom by ſpirits of wine.

Gums diſtinguiſhed from reſins principally from their ſolubility in water, and inſolubility in ſpirits of wine, and by their being neither fuſible, nor inflammable in fire.

Gum arabic diſtilled—Acid—Oil—Volatile alkali—Caput mortuum.

Of Gummy Reſins.

Gum *ammoniac* diſſolved in ſpirits of wine.

Gum ammoniac dissolved in water.

Of *assa fœtida*, myrrh, frankincense, and other gummy resins.

OF VEGETABLE JUICES OBTAINED BY TRITURATION, AND EXPRESSION.

Of essential Salts of Plants.

Native aqueous juices expressed and clarified.

Native aqueous juices evaporated and crystallized—Essential salts.

Of neutral salts contained in vegetables.

History of sugar, and of the method of preparing it.

Brown or gray Muscovade—Melasses, or treacle.

Method of refining sugar.

Sugar dissolved in water and crystallized—*Saccharum candum, et crystallinum.*

Sugar

Sugar diſſolved in rectified ſpirits of wine, and cryſtallized.

Refined ſugar diſtilled—Acid—Oil—Air—Caput mortuum.

Of ſaccharine juices obtainable from maple trees, birch trees, ſycamore trees, &c. by tapping; from fruits and roots of various kinds, by ſolution in ſpirits of wine; from the ſpontaneous exudations of the *fraxinus rotundiore folio*, and other trees producing *manna*; and from various flowers affording honey to the bee.

Native juices of vegetables inſpiſſated to different conſiſtencies—Liquid or ſolid extracts by expreſſion.

Of *aloes*, *opium*, *acacia vera*, and other ſolid extracts by expreſſion.

Of expreſſed Oils.

Oils obtained by expreſſion from

linſeed, muſtard ſeed, ripe olives, almonds, walnuts, &c.

Expreſſed oils diſtinguiſhed principally from eſſential oils, in not being ſoluble in ſpirits of wine, nor volatile in the heat of boiling water, and in having ſcarce either taſte or ſmell.

Method of impregnating expreſſed oils with the odorous principle of violets, lilies, roſes, &c.—Various perfumes.

Oil of olives diſtilled—Phlegmatic acid—Oil—Fixed oil—Caput mortuum.

Of the rancidity of expreſſed oils.

Expreſſed oils ſuſpended in water by means of mucilages—Emulſions—Milky juices of plants.

Of the combination of oils with fixed alkali.

Fixed alkali deprived of its fixed air

air by quicklime—Caustic alkali—Soap lees.

Soap lees inspissated—*Cauterium potentiale, lapis infernalis.*

Oil of olives, oil of turpentine, train oil, tallow, &c. dissolved in soap lees—Soaps of various kinds.

Solution of soap in distilled water, and in spirits of wine.

METHOD OF ANALYZING VEGETABLES FURTHER EXPLAINED, BY INFUSION, AND DECOCTION IN VARIOUS MENSTRUUMS.

Carduus Benedictus infused in cold water.

Carduus benedictus boiled in water.

Peruvian bark infused in cold water.

Peruvian bark boiled in water.

 Jalap

Jalap digested with spirits of wine —Tincture of Jalap—Residuum.

The residuum of the preceding process boiled with water and inspissated—Aqueous extract of jalap.

Resin of jalap precipitated from tincture of jalap by water.

Method of obtaining the resinous and gummy parts of vegetables, and of making spirituous, aqueous, and mixt extracts.

Aqueous decoction of red saunders.

Spirituous decoction of red saunders.

Aqueous decoction of Brazil wood.

Spirituous decoction of Brazil wood.

Aqueous decoction of alkanet root.

Spirituous decoction of alkanet root.

Red saunders digested in oil of turpentine.

Alkanet

Alkanet root digeſted in oil of turpentine.

Archel boiled in water, in oils, in acids, in ſpirits of wine, in fixed alkalis, and in volatile alkalis.

The colouring matter of ſome vegetables precipitated by allum, ſolutions of tin, &c.—*Lakes.*

Various experiments relative to the production, change, and recovery of colours, by different ſaline additions to coloured vegetable infuſions.

Of dying in general.

METHOD OF ANALYZING VEGETABLES BY DISTILLATION, EXEMPLIFIED IN VARIOUS INSTANCES, AND VARIOUS DEGREES OF HEAT.

Mint, thyme, roſemary, lavender, or other aromatic plants diſtilled

with a heat *leſs* than that of boiling water and *without* addition—*Spiritus rector*, or odorous principle.

The ſame plants diſtilled *with* the addition of water, and with the *heat* of boiling water—Eſſential oils—Aromatic or ſimple diſtilled waters.

Of the different weights, colours, and conſiſtencies, of eſſential oils.

Eſſential oils by expreſſion from oranges, citrons, &c.

Method of obtaining them in Italy.

Eſſential oils ſoluble in ſpirits of wine.

Roſemary tops, lavender flowers, &c. diſtilled with ſpirits of wine—Spirit of roſemary, ſpirit of lavender, &c. more commonly called Hungary water, lavender water, &c.

Eſſential oil of roſemary, and of lavender, precipitated from Hungary water

water and lavender water, by the affusion of water.

Of distilled spirituous waters.

Rosemary, &c. after the extraction of their essential oil, distilled to dryness—Phlegm—Acid—Empyreumatic oil—Caput mortuum.

Method of making charcoal explained.

Charcoal not acted upon by water, acids, alkalis, vinous spirits, or oils.

Charcoal decomposed by burning —Phlogiston Residuum.

Quantity of residuum from a given weight of charcoal estimated.

Fixed alkaline salt and earth obtained from the residuum.

Of the method of manufacturing and depurating pot-ash.

Of the difference between the mineral fixed alkali, or *natron* of the ancients, and the vegetable fixed alkali.

Analysis of Woods.

Oak distilled *balneo Mariæ*—Phlegm—Residuum.

Residuum distilled — Phlegm — Acid air—Oil lighter and heavier than the acid—Caput mortuum.

Air from oak not destructive of flame, but inflammable after passing through water, and through fixed alkaline lixivia, and retaining its inflammability for several days.

Of the different quantities of charcoal, of liquid contents, and of fixed air obtained from equal weights of oak, box, hazel, willow, and other woods, by distillation.

Of the best kinds of charcoal requisite for the making of gunpowder, fluxing of metals, &c.

Volatile alkali disengaged from the acid of oak by fixed alkali.

Acid

Acid of box-wood rectified.

Rectified acid of box saturated with vegetable and mineral fixed alkalis—Nature of neutral salts from the distilled acids of vegetables.

Analysis of the *Tetradynamia* of Linnæus.

Mustard seed, pepper wort, &c. distilled with the heat of boiling water—Phlegm sapid and odorous, but neither manifestly acid nor alkaline.

Mustard seed, &c. distilled with a degree of heat superior to that of boiling water—Volatile alkali, acid, air, oil, caput mortuum.

Of Soot.

Wood soot distilled—Acid—Volatile alkali—Empyreumatic oil—

Sal

Sal ammoniac—Caput mortuum, yielding fixed alkali.

Of Wax.

Wax diftilled — Acid — Oil — Congealed oil—Caput mortuum.

Congealed oil or butter of wax, rectified—Acid—Yellow oil—Fat brown refiduum.

Methods of bleaching yellow wax, and of colouring bleached wax.

OF FERMENTATION IN GENERAL.

Of the vinous Fermentation.

Hiftory and ufe of *malting* as preparatory to the fermentation of farinaceous feeds.

Equal weights of barley, rye, wheat, oats, beans, peas, converted into malt, and after decoction for the fame time in equal quantities of

of water exposed to fermentation—*Ale* of different sorts.

The medium heat of fermenting wort estimated by the thermometer, and shewn to be equal to the medium heat of an animal body.

The air generated during the vinous fermentation shewn to be deleterious to animal life and to flame.

The specific gravity of air, generated by vinous fermentation, proved by the Hon. *Henry Cavendish* to be greater than that of common air, and to be equal to that separable from marble by solution, or about 511 times lighter than water, when common air is supposed 800 times lighter.

Equal weights of raisins, refined sugar, brown sugar, treacle mixed with equal quantities of water and fermented—*Wines* of different kinds.

Ale diſtilled—Malt ſpirits—reſiduum.

Wine diſtilled — Brandy — Reſiduum.

Potatoes fermented and diſtilled—*Potatoe brandy*.

Of the methods of making malt ſpirits, brandies, rums, arracks, and the origin of their different odours and flavours explained.

Malt ſpirits, brandy, &c. diſtilled —*Alcohol*, or rectified ſpirits of wine —Acidulated phlegm.

Of the identity of alcohol from whatever fermented liquor it is diſtilled.

Of *proof ſpirit*.

Uſual methods of eſtimating the ſtrength of brandies, rums, &c. and their imperfections.

Alcohol and water mixed together, the bulk of the mixture ſhewn

to

to be considerably *less* than the sum of the separate bulks.

Method of judging accurately concerning the strength of spirituous liquors pointed out.

Of the arrack or *cosmos* prepared by the *Calmuck Tartars* from mare's milk.

Method of obtaining white and red *tartar*.

Tartar purified—Cream or crystals of tartar.

Tartar distilled—Acid—Air—Oil—Volatile alkali—Caput mortuum.

Fixed alkaline salt extracted from the caput mortuum of distilled tartar without burning it.

Crystals of tartar combined with absorbent earths.

Crystals of tartar combined with the fixed alkali of tartar— *Sal vegetabilis, tartarus tartarisatus.*

Cryſtals of tartar combined with the fixed alkali—*Sal polychreſtus de Saignette—Rochelle ſalt.*

Cryſtals of tartar combined with volatile alkali.

OF THE ACETOUS FERMENTATION, OR THE SPONTANEOUS CONVERSION OF ALES AND WINES INTO ALEGARS AND VINEGARS.

Method of making vinegars, and of diſcovering whether they are adulterated with oil of vitriol.

Vinegar diſtilled—Phlegm—Acid—Extract.

Method of diſcovering whether vinegar be depraved by lead.

Extract of vinegar diſtilled—Acid—Empyreumatic oil—Volatile alkaline ſalt, and ſpirit— Caput mortuum.

Vinegar

Vinegar concentrated by *freezing* the phlegmatic part.

Diſtilled vinegar combined with abſorbent earth.

Diſtilled vinegar combined with the fixed alkali of tartar—*Sal diuretticus*—*Terra foliata tartari*.

Diſtilled vinegar combined with the mineral fixed alkali, and cryſtallized.

Diſtilled vinegar combined with volatile alkali—*Spiritus Mindereri*—Acetous ſal ammoniac.

Combinations of the acid of tartar with the vegetable and fixed alkalis, decompoſed by the acid of vinegar.

Difference between the acid of tartar and that of vinegar.

Of the putrefactive fermentation of vegetables.

OF ANIMALS.

General analysis of animal fluids exemplified in the analysis of milk, blood, urine, and whites of eggs.

Of Milk.

Cows milk distilled *balneo mariæ*—Phlegm transparent, colourless, insipid—Unctuous saline residuum.

Asses milk distilled balneo mariæ—Phlegm—Residuum.

Proportion of phlegm separable from equal weights of cows milk and asses milk by distillation B. M. ascertained.

Equal weights of cows milk, goats milk, woman's milk, asses milk,

milk, evaporated to dryneſs—Proportion of the reſiduums, and of the ſaline and earthy matter contained in them.

Reſiduum from the diſtillation of milk B. M. diſtilled—Acid—Empyreumatic oil—Volatile alkali—Caput mortuum, containing fixed alkali.

Milk ſpontaneouſly ſeparated into cream and ſkim-milk.

Cream reſolved into butter—Curd—Whey.

Skim-milk reſolved into whey—Curd—Butter.

Butter diſtilled—Acid—Oil—Caput mortuum.

Curd diſtilled—Alkali volatile in a fluid and concrete form—Fetid oil—Caput mortuum.

Whey evaporated and cryſtallized—*Sugar of milk—Sea ſalt.*

Milk not coagulable by the heat of boiling water.

Milk coagulable by acids, by alkalis, by vinous ſpirits, by ſome neutral ſalts earthy and metallic.

Of Blood.

Blood examined by a microſcope —Tranſparent fluid—Red globules of various ſizes.

Blood warm from the vein diſtilled balneo mariæ—colourleſs, inſipid phlegm—Reſiduum.

Of the quantity of phlegm contained in the blood of different animals, and ſeparable therefrom by the heat of boiling water.

Phlegm, impregnated with volatile alkali, obtained from blood by the heat of a boiling fixed alkaline lixivium.

Blood

Blood exſiccated by the heat of the ſun.

Blood exſiccated by the heat of the ſun, or by diſtillation B. M. not ſubject to putrefaction.

Exſiccated blood diſtilled—Volatile alkaline ſpirit and ſalt—Air—Empyreumatic oil — Caput mortuum.

Blood ſpontaneouſly reſolved, by expoſure to the air, into a fluid and coagulated part—*Serum*—*Craſſamentum*.

Account of Mr. *Hewſon*'s experiments, relative to the cauſe of the ſpontaneous coagulation of blood when taken out of an animal body.

Blood prevented from ſpontaneous coagulation by ſea ſalt, and other neutral ſalts.

The *craſſamentum* reſolved, by ablution, into a white fibrous part,

called by ſome the coagulable lymph, not ſoluble in water, and a red colouring part, called the red globules, reckoned ſoluble in water.

The fibrous part or coagulable lymph diſtilled.

The red globular part diſtilled.

The ſerum coagulated by boiling water, by acids and by vinous ſpirits.

Of Urine.

Freſh Urine gives no marks of containing either acid or alkaline ſalts.

Freſh human urine diſtilled B. M. —Colourleſs phlegm with an urinous ſmell—Reſiduum.

Reſiduum diſtilled—Volatile alkali in a fluid and concrete form—Oil—Sal ammoniac—Caput mortuum, yielding ſea ſalt by elixation, and fixed alkali by calcination.

Horſes

Horſes urine diſtilled—Phlegm—Volatile alkaline ſpirit—Oil—Caput mortuum, yielding fixed alkali without calcination, and ſea ſalt by elixation.

Human urine evaporated and cryſtallized—Fuſible, eſſential, native, microcoſmic, phoſphoric ſalt of urine—Sal ammoniac—Sea ſalt.

Horſes urine, evaporated to a due conſiſtency, does not yield a fuſible ſalt, but a portion of ſea ſalt and a magma incapable of cryſtallization.

Earth from the exſiccation of human urine rendered white by calcination—Its habitude to fire and menſtruums examined.

Account of Marggraf's experiments on the fuſible ſalt of urine.

Volatile alkali ſeparated from

ſreſh urine by fixed alkali and by lime.

Of Eggs.

Whites of Eggs coagulated nearly by the ſame degree of heat which coagulates the ſerum of blood.

Whites of eggs coagulable by acids and by ſpirits of wine—their uſe in clarification.

Whites of eggs diſtilled B. M. —Phlegm—Reſiduum.

Reſiduum diſtilled—Volatile alkali concrete and fluid—Empyreumatic oil—Caput mortuum.

Oil expreſſed from the yolks of eggs.

Of the eſſential oil, volatile acid, and expreſſed oil of ants.

Of

Of Coral, &c.

Volatile alkali procured from coral and ſpunges by diſtillation.

Of Brains and Spermaceti.

Contents of a human cranium diſtilled—Phlegm—Volatile alkali —Fetid oil—Caput mortuum.

Of Fat.

Suet diſtilled—Acid—Congealed oil—Caput mortuum.

Of Bones and Horns.

Horns rendered ſoft and flexible by boiling in water.

Ox horn, tortoiſe ſhell, &c. diſſolved in acid of nitre.

Bones ſoftened, and in part diſſolved, by digeſtion in acids.

Earth of bones precipitated from acids by alkalis.

Gelatinous

Gelatinous and faline part extracted from hartfhorn by boiling in water—Method of making glue—Portable foup—Ifinglafs—Size, &c.

Inert earth remaining after the extraction of gelly of hartfhorn—*Cornu cervi philofophicè calcinatum.*

Hartfhorn diftilled — Phlegm— Volatile alkaline falt and fpirit— Air — Empyreumatic oil — Caput mortuum.

Method of preparing volatile alkaline falt and fpirit from bullocks bones, &c.

Animal oil diffolved in fpirits of wine.

Animal oil rectified—*Oleum animale Dippelii.*

Hiftory of Putrefaction.

Cauftic volatile alkali rendered mild

mild by the air difcharged from putrefcent bodies.

Volatile alkali feparated with the heat of boiling water from putrid blood, pigeons dung, and putrid urine.

Hiftory of *Kunckel's* phofphorus.

Phofphorus made by diftilling the extract of urine with *plumbum corneum* and charcoal, according to Marggraf's method.

Phofphorus made by diftilling fufible falt of urine and charcoal together.

Method of rectifying phofphorus.

Several experiments with phofphorus.

Of other vegetables which yield a phofphorus by diftillation.

Analyfis of the *fæces alvinæ*.

TRACT VII.

Institutiones Metallurgicæ.

PRÆFATIO.

MIRUM profecto et incredibile dictu est, quam late per universas Europæ regiones sese dilataverit Philosophia Naturalis, ex quo Peripateticorum atque Aristotelis Auctoritatem fregerit Baconus. Hinc æque singulorum, ac Societatum et Academiarum Laboribus Commentariisque, adeo jam diffusa est undique et disseminata, ut ingentes ejus Auctus et Progressus Cogitatione vix quisquam poterit complecti.

Jacebat interea *Chemia* parcius et infrequentius culta, sanis plerisque suspecta, et, Alchemicorum propter deliramenta, ab ipsa Legum nostrarum auctoritate improbata. At ut aliis rebus

bus humanis ita etiam et Artium ſcientiis accidit, quæ nec in imo gradu neque in faſtigio moram patiuntur.

Chemiam, quam haud ita pridem fuiſſe audivimus domi ſqualidam, fuligine inſuſcatam, et præ hominum ei deditorum pauperie pene ridiculam, foris per trivia miſere vagantem, inhianti paſſim popello præſtigias ſuas venditantem, a nemine fere non conculcatam et deſpectui habitam, noſtris tandem temporibus ſeſe alacrius erigentem, focillatam demum a Principibus, et a Philoſophis ubique excultam auſpicato ſatis admiramur. Eò quidem jam perducta eſt, ut quæ inter præcipuas plane doctrinas reponatur omnino digna ſit, cum nec in Principiorum perſpicuitate nec in Concluſionum pondere, ſive philoſophicos ſeu civiles reſpicias uſus, ulli ſcientiarum cedat.

Chemia genere *duplex* eſt; corpora vel *reſolvit* vel *componit*. Reſolutio corporum iiſdem, quibus ipſa eorum varietas ſpecifica, terminis definitur; ſingulorum abſoluta eſſe habetur cum ad *Elementa* vel principia homogenea, ſive plura ſint ſive pauciora, perducatur.

catur.—Compoſitio corporum, Geometriæ inſtar, eſt infinita.

Partium Animalium figuram, nexum, et motum Anatomici; Vegetabilium fabricam Botanici: Foſſilium ſitus atque habitus externos Mineralogici; non formas rerum ſed mixtiones Chemici, perſcrutantur.

Actiones Medicamentorum in corpora animalium tractat *Therapeutice*. Chemia autem quippe quæ reſolvat mixta, reſoluta conjungat, et varia quæ inde exoriantur phænomena dignoſcat Therapeutices ſit quaſi anima: at cum infinitas ſimul aliorum corporum naturas retegat, et actiones mutuas inveſtiget, ad univerſam potius Phyſicen, quam ad ſolam medicinam, tanquam ad ſuum ac proprium finem refertur.

Mechanica tum Phyſices tum Chemiæ ſanioris fundamenta feliciter poſuit *Newtonus*; cum de mutuis corporum Attractionibus, vel, ut Chemici loquuntur, Affinitatibus, ex quibus omnis eorum Reſolutio et Compoſitio pendet, in quæſtionibus quibuſdam ſuo de re optica libello adjectis quam ſa-

gaciſſime

gacissime disceptavit; fundamento jam posito molem extruxere paululum Recentiores, felici admodum solertia; nec Ædificio Adminiculum nec forma deest: Fastigium Operi quod infinitum est, nulla ingeniorum sagacitas, nulla temporum diuturnitas unquam imponet.

In *Theoreticam* et *Practicam* commode dividi potest Chemia: hæc quæ Encheireses docet, Opificum est; illa quæ veritatem exquirit, Philosophorum. Veritatis indagatio omnis est Philosophiæ finis, hæc autem veritas inter physicos cognitione rerum experimentis eruenda continetur. Chemia quoque infinitam propemodum experimentorum, cum multis ante seculis tum nostra etiam ætate institutorum, copiam complectitur, atque iisdem universa nititur.

Notiora tanquam ignota proferre, depeculari aliena, antiqua undique corrasa tanquam nova ac propria venditare, hominis est otio abutentis: At simulata a sinceris distinguere, dubia secernere a certis, indigestis nexum quendam conciliare et ordinem, obscuriora illuminare, infinitis modum

statuere,

ſtatuere, arduum ſane ſed nec inutile nec inhoneſtum eſt. Quod ſi magno cum diſcentium commodo, in aliis philoſophiæ naturalis partibus abſolutum hocce vidimus, quid obſtat quo minus in Chemia quoque induſtriæ aliquid periclitemur? Hac mente Provinciam mihi ab Alma Matre demandatam, *Regis Ornatiſſimi* munificentia inſignitam ſimul ac ditatam, quantum in me fuerit colui, et colam.

Lectores nihil hic reperient præter *Corporum Metallicorum Affectiones* cum alienis tum meis quibuſdam experimentis enucleatas; quas in ſeriem Propoſitionum, brevem quidem at Lectionibus publicis explicandam et illuſtrandam redegi.

Opuſculum hoc Tyronum gratia, currente calamo conſcriptum, utcunque imperfectum et provectiorum notitia indignum, iis qui Chemiam a limine tantum ſalutant, vix erit inutile. Et cum nollem id extra Academiæ pomœrium evagari aut publici fieri juris, erroris ſi quid aut incuria fuderit, aut ab ipſius operis obſcuritate et difficultate irrepſerit, id ſolita pro ſua huma-

nitate condonent oro, qui hic loci Chemiæ operam navarunt : iiſque mei adverſum ipſos ſtudii, pietatis erga Academiam hoc qualecunque Teſtimonium, omni cum cultu et obſervantia, dico atque dedico.

CAP. I.

Definitiones.

1 CORPORA quæ ponderis decrementum in igne fortiſſimo non patiuntur *Fixa* vocantur, quæ patiuntur *Volatilia*; idque magis aut minus prout majori aut minori negotio partes eorum igne diſſipantur.

2 *Partes volatiles* corporis, quæ fluidæ ſunt et ignis vi in auras agantur, *evaporari* dicuntur; cum in vaſe clauſo ſtillatim condenſentur, *diſtillari*; *Solidæ* vero, cum ſurſum evectæ in forma ſolida condenſentur, *ſublimari* dicuntur: atque hæ vel *Sublimata* vel *Flores* vocantur, prout maſſam compactam, vel pulverem friabilem efficiunt.

3 Fluidum quodvis, ſolido affuſum et ab eo diſtillatione ſeparatum, dicitur ab eo *abſtrahi*.

4 Cum partes aquoſæ fluidi cujuſvis compoſiti ab eo ſeparantur, ſive diſtillatione, ſive corporum aquam vel phlegma

 abſcr-

absorbentium interventu, sive conglaciatione, fluidum remanens *dephlegmari* vel *concentrari* dicitur.

5 Corpora, quæ vel culinari vel solari igne, sive ipsa ignis vi, sive aqua postea affundenda (ut fit in lapidibus calcareis) in Pulverem *fragilem*, *friabilem*, terræ similem fatiscunt, *calcinari* dicuntur: Pulvis iste *Calx* appellatur; præsertim si corpora sint ex regno minerali desumpta. Corpora quoque, cùm in hujusmodi Pulverem Acidis corrosa dejiciantur, nonnunquam dici solent *in Calcem redigi*.

6 Corpora *via humida dissolvi* dicuntur, cum partes eorum fluido cuivis ita adjunguntur, ut unum quasi cum eo corpus visu homogeneum constituant, in eo suspensæ maneant, nec tamen id opacum vel turbidum reddunt.

7 Corpora sicca, quæ aeri exposita fiunt fluida, *deliquescere* vel *Deliquium pati* dicuntur.

8 Fluidum, quo corpora dissolvuntur, *Solvens* aut *Menstruum* vocatur.

9 Menstruum, cum de corpore solvendo nihil amplius in se recipere et sustinere potest, *saturari* dicitur.

10 Sepa-

10 Separatio corporis a menſtruo quo ſolutum eſt, ſive ſpontanea ſit ſive coacta, et ſive ſurſum ſive deorſum fiat, *Præcipitatio humida* dicitur; atque Materia ad imum dejecta, vel ad ſummum evecta, *Magiſterium* vel *Præcipitatum* vocatur.

11 Cum partes corporis ſolidi adeo a ſe invicem vi ignis expandente ſeparantur ut fiant fluidæ, corpus *fuſum* vel *liquatum* eſſe dicitur.

12 Corpora heterogenea, quæ igne fuſa, diverſa particularum gravitate in duas partes interea ſeparantur, *Præcipitationem ſiccam* vel *fuſoriam* ſubire dicuntur. Pars illa quæ gravitate ſua majori imum petit, *Regulus*, altera huic ſuperincumbens *Scoria* appellatur.

13 *Eliquatio* eſt cum eo ignis gradu in quo altera Mineræ compoſitæ pars ſolida ſeu refractaria manet, altera fluit et ab illa ſeparetur.

C A P. II.

De Subſtantiis metallicis in genere.

1 SUbſtantiæ metallicæ, arte metallurgica e mineris, eductæ et fuſione purgatæ, ſunt corpora omnium

 longè

longè ponderosissima et (nisi subtilius partes dividantur) opacissima, aqua non solubilia, igne fusilia, at calore atmosphæræ terrestris (Mercurio excepto), non fluida, fulgore et nitore peculiari insignia. Hæ in duas classes, alteram Metallorum, alteram Semi-metallorum distribui solent.

2 Metalla, quæ hactenus cognita sunt, sex vulgo numerantur; Aurum, Argentum, Plumbum, Cuprum, Ferrum, et Stannum.

3 Semi-metalla habentur Platina (quæ metallis potius annumerari debeat), Argentum vivum, Regulus Antimonii, Bismuthum, Zincum, Regulus Cobalti, et Nickel. Ad hæc ab omnibus fere, at temere forsan, adjungitur Regulus Arsenici.

4 Metalla a Semi-metallis majori sua malleabilitate præcipue distinguuntur.

5 Metalla fere dividuntur in duos ordines, metalla perfecta seu nobilia, et metalla imperfecta seu ignobilia. *Perfecta* habentur Aurum et Argentum; quibus adjungi debet Platina. Reliqua *imperfecta* esse deprehenduntur.

6 *Metalla perfecta* sunt, quæ in igne violentissimo et fixa manent, et calcinationem

nationem nullam patiuntur : *imperfecta*, quæ in igne et calcinationem patiuntur et partium dissipationem.

7 Omnes substantiæ metallicæ, exceptis forsan Auro, Platina, Argento et Argento vivo, si in igne aperto comburantur, in calces convertuntur, quæ difficilius aut facilius vitrificationem admittunt prout calcinationem magis minusve perfectam subierint.

8 Calces et vitra metallica, cum Carbone, Oleo, Sevo, aliisve substantiis Phlogiston debito statu in se continentibus, præsertim in vase clauso, igni exposita in formam suam pristinam metallicam reducuntur, modo calcinationem nimiam non perpessæ sunt; ipsa operatio vocatur *Reductio*.—Annon omnes Substantiæ Metallicæ constant ex terra vitrescente et substantia inflammabili? Quod si Phlogiston sit uniforme quiddam sibi ubicunque reperiatur simile, quæri potest 1^mo^ num terræ metallicæ ab aliis omnibus terris vitrescentibus genere discrepant: et proinde, num Arte Chemica substantiæ Metallicæ generari queant: 2° utrum substantiarum Metallicarum dif-

ſerentia oriatur a ſpecifica quadam terrarum differentia; an a diverſa proportione et nexu quibus eadem terra cum Phlogiſto conjungitur; an ab interpoſitione aliorum quorundam corporum: et proinde poſſint necne in ſe invicem tranſmutari?

9 Subſtantiæ Metallicæ, fuſione inter ſe miſtæ, raro magnitudinem illam habent quæ oriri debeat a magnitudinibus partium componentium ſimul ſumptis. In quibuſdam vero, ut in mixtura Stanni et Cupri, decrementum magnitudinis et incrementum gravitatis ſpecificæ ſunt admodum notabilia. In aliis, ut cum Stannum et Zincum una colliquantur, tantum eſt magnitudinis incrementum, ut gravitas ſpecifica ſive denſitas mixturæ minor ſit gravitate ſpecifica corporis levioris. In mixtura Cupri et Biſmuthi ea fere deprehenditur denſitas quæ ſecundum regulas communes hydroſtaticas expectari debeat.

10 Quædam ſubſtantiæ Metallicæ, ex. gr. Aurum, Argentum, Cuprum, Plumbum, Stannum et Zincum, igne fuſæ adeo magnitudine augeri, et ſpecifica gravitate diminui dicuntur, ut

frustulum solidum ejusdem materiæ, cuilibet earundem cum fluidæ sint injectum, submergatur et in fundum subsidat; ut fit in Sevo, Cera et Resinis liquefactis: Aliæ, ut Bismuthum, Antimonium, et præcipuè Ferrum, adeo diminui dicuntur magnitudine, ut solidum frustulum iis innatet, quemadmodum sulphur solidum sulphuri liquato aut Glacies aquæ innatat.

11 Plurimæ, fortasse omnes, Substantiæ Metallicæ igne satis fusæ et lentius postea frigefactæ, partium quandam regularem dispositionem vel *Crystallisationem* in superficie visibilem, sed in diversis generibus diversam, acquirere dicuntur.

12 Omnes Substantiæ Metallicæ calore dilatantur, frigore contrahuntur. Hæc magnitudinis mutatio, Pyrometro mensurata, minor esse observatur in Regulo Antimonii, et major in Zinco, quam in alia quavis Substantia Metallica.

13 Omnes Substantiæ Metallicæ citius et calescunt et refrigescunt quam aut Spiritus Vini, aut Olea, aut alia ulla corpora: et hinc Thermometris

et Pyrometris conficiendis adprimè aptæ ſunt.

14 Subſtantiæ Metallicæ, nec in directa nec in reciproca ratione denſitatis, cohærentiæ, duritiei, nec in ratione quavis ex his quocunque modo compoſita, nec denique ſecundum ullam generalem legem huc uſque repertam, calorem vel acquirunt vel amittunt.

15 Corpora Metallica fuſa omne cum ſalibus et terris etiam metallicis reſpuunt connubium, ſuperficiem convexam habent; præterquam quod ſi fuſa ſint in vaſis metallicis ab horum lateribus partes contiguæ attrahuntur quaſi, et ſuperficiei convexitas deſtruitur. Si cum ſulphure liquifiant, omnia (præter Aurum et Zincum) in mineras, iis quæ e fodinis eruuntur ſimiles, et ab iis vix diſtinguendas, convertuntur: cum Arſenico, omnia per fuſionem uniuntur, et ab eo fragilia redduntur.

16 Metalla quædam, uti Ferrum, Cuprum et Argentum, quæ ignem ut fluant fortiſſimum poſtulant, ſulphure addito citò liqueſcunt: dum alia quædam,

dam, uti Plumbum et Stannum, per se satis fusilia, cum Sulphure conjuncta fiunt admodum refractaria.

CAP. III.

De Argento vivo sive Mercurio.

1 MERCURIUS est corpus metallicum tactu frigidum, omnium (Auro et Platina exceptis) ponderosissimum; eo propemodum caloris gradu quo aqua ebullit aut etiam minori, volatile; corpora, nisi metallica, non madefaciens; Atmosphæræ terrestris calore fluidum.

2 Mercurius frigore artificiali, a mistura spiritus nitri fumantis cum nive orto, in solidum mutari potest.

3 Mercurius frigore in solidum constrictus est metallum eximio nitore splendens; mallei patiens; duritie et sono quem reddit plumbo persimile.

4 Magnitudo Mercurii frigore fixi minor esse dicitur parte circiter 10^{o} quam magnitudo ejusdem Mercurii ad ebullitionem calefacti.

5 Mer-

5 Mercurius, cum jamjam ſit vel in calore ebulliturus, vel in frigore fluiditatem ſuam amiſſurus, celeriter aſcendere et deſcendere obſervatur.

6 Mercurius purgatiſſimus, diu multumque agitatus, converti poteſt aliqua ex parte, forſan omnis, in pollinem nigerrimum ſaporis acris, metallici æneí, qui igne valido, nullâ re additâ, diſtillatus fit *Mercurius vivus* vel *currens*.

7 Mercurius, in igne mitiori vaſe clauſo diutius detentus, in pollinem nigrum antecedenti ſimilem mutatur: in igne fortiori digeſtus quaſi calcinatur in pulverem primo cineraceum, deinde flaveſcentem, tandem rubrum; qui impropriè vocatur *Mercurius præcipitatus per ſe.*

8 Mercurius calcinatus vel præcipitatus per ſe, ipſo Mercurio ponderoſior eſt et in igne fixior. Adaucto nihilominus calore diſſipatur; remanente perparva quantitate pulveris fuſci, qui vitro uſtorio in vitrum fuſcum mutatur: dum mercurius qui calcinationem non paſſus eſt, ab eo calore, nullo reſtante reſiduo, in auras pellitur.

9 Mer-

9 Mercurius quingenties amplius diſtillatus, ſingulis vicibus ſemper quiddam pulveris rubri in retorta reliquit; at aliam non ſubiit mutationem.

10 Mercurius præcipitatus per ſè, in igne culinari, nullo addito Phlogiſto, maxima ex parte reviviſcit. Reſiduum igne fortiſſimo fixum eſt: fuſum cum Borace, in maſſam friabilem vitreſcentem vertitur; cum Plumbo cupellatum, prorſus evaneſcit.

11 Acidum Nitri mercurium facile diſſolvit. Solutio evaporata, præbet Cryſtallos albas, acerrimas, longas, nonnunquam et tenues nitro ſimiles: inſpiſſata, in maſſam vertitur albam, ſalinam, admodùm cauſticam, quæ æque ac cryſtalli igni in patella expoſita fit pulvis, primo albus, deinde flavus, tandem dum calidus manet purpureus, ſed frigeſcens ruberrimus; qui vocatur *Mercurius præcipitatus ruber*.

12 Acidum Vitrioli Mercurium vix diſſolvit, niſi ſit ebulliens et concentratum. Si diſtilletur, odorem ſulphureum a Mercurio acquirit, et Mercurius ſimul corroſus fit maſſa ſalina, alba,

alba, quæ in igne violentiori colorem non mutat, aere non deliquefcit, et aquam calidam affundendo partim in ea diffolvitur, partim mutatur in pulverem flavedinis eximiæ, qui fervida aqua fæpius ablutus fit infipidus; et vocatur *Mercurius emeticus flavus*, vel *Turpethum minerale*.

13 Acidum marinum in Mercurium non agit viâ humidâ; at in vapores refolutum, et ei per fublimationem variis modis conjunctum, falem cryftallinum femipellucidum conftituit; qui vocatur *Mercurius fublimatus corrofivus*, tunc viribus rodendi maximis pollens, cùm proportio Acidi, refpectu habito ad Mercurium, fit maxima.

14 Mercurius fublimatus, maximè corrofivus, cum ea quantitate Mercurii crudi tritus quæ fufficiat Acido marino perfectè faturando, et fublimatus fit opacus, aqua non folubilis, vis rodentis expers, et *Mercurius dulcis fublimatus* nuncupatur.

15 Acida vitriolica et marina iis qui Propofitionibus 12ª et 13ª explicantur modis cum Mercurio uniuntur. Quòd fi Acida hæc vel Solutio falis cujuflibet

medii, in quo alterutrum continetur, in Mercurium Acido nitri ſolutum infundantur, Mercurius ſeſe iis adjunget et pulveris albi forma præcipitabitur. Pulvis, hic ſi cum Acido vitriolico conjungatur, fit *Turpethum minerale*; ſin ab Acido marino præcipitatio fiat, *Mercurius præcipitatus albus* vocatur, ſublimato corroſivo vel dulci accedens prout ſit vel non ſit edulcoratus.

16 Mercurius ſublimatus corroſivus, aqua ſolutus, ab Alkali fixo in fundum præcipitatur in forma pulveris rubri: ab aqua calcis præcipitatus fit flavus; ab Alkali volatili albus: a miſtura Alkali fixi et Alkali volatilis paribus quantitatibus albor nihil inquinatur.

17 Spiritus vini rectificatus, et ebulliens, ſuum pene pondus Sublimati corroſivi; ad gradum 16^{m} Thermometri Reaumeri aut 68^{m} Fahrenheitii calefactus, tres octavas ponderis ſui partes, diſſolvit.

18 Spiritus vini rectificatus, ad gradum 68^{m} Thermometri Fahrenheitiani calefactus, et Sale Ammoniaco ſaturatus, Sublimati corroſivi tres quartas ponderis ſui partes diſſolvit: et proinde

vis

vis ejus ſolvendi Sublimatum corroſivum Salis Ammoniaci additione duplicatur.

19 Aqua, cum ebulliat, dimidium ſuum pondus de ſublimato corroſivo; ſi ad quinquageſimum tantùm gradum Ther. Fahren. calefiat, vix partem ſui ponderis vigeſimam, diſſolvit.

20 Aqua, Sale Ammoniaco ſaturata et ad prædictum gradum calefacta, Sublimati corroſivi duas tertias partes ponderis ſui diſſolvit: et proinde majorem habet vim ſolvendi hunc ſalem quam aqua ſimplex in proportione fere, 40 : 3.

21 Si Mercurius cum Sulphure teratur, aut cum Sulphure liquato miſceatur, pulverem fuſcum, cito in nigrum abeuntem, conſtituit; qui vocatur *Æthiops mineralis.* Hic autem ſublimatione fit maſſa rubra, friabilis, ſtriata, quæ *Cinnabaris factitia* nuncupatur; a Cinnabari nativa, quando debita ſulphuris portio adhibita fuerit, vix diſtinguenda.

22 Si Cinnabaris factitia, aut nativa, miſceatur cum Alkali fixo, Calce viva, Limatura Ferri, aliiſve rebus, quibus major

major cum Sulphure competit affinitas, quam ipſe habet Mercurius, et diſtilletur, *Mercurius* obtinebitur *purgatus*. Aliquid etiam Sulphuris quod ab Acidis præcipitari poteſt a cinnabari, ea cum Alkali fixo decoquenda, extrahitur.

23 Mercurius Plumbum, Stannum et Aurum facillime penetrat et friabilia reddit; et cum omnibus quidem Subſtantiis Metallicis (Nickel et Regulô Cobalt forſan exceptis) quanquam cum Ferro, Antimonio et Ære paullò difficilius, vel trituratione frigida aut calida, vel fuſione, coit, Mixtura inde proveniens vulgò *Amalgama* rectius *Malagma* dicitur: quod eſt mollius, friabilius, fluidius, aut ſpiſſius pro diverſa quantitate Mercurii in eo conficiendo adhibiti.

24 Amalgama Mercurii et Argenti gravitatem habet ſpecificam majorem gravitate ſpecifica ipſius Mercurii.

25 Acida vegetabilia et Sales alkalini eâdem fere methodo in Mercurium, quâ in Aurum et Argentum, agunt.

C A P. IV.

De Antimonio et ejus Regulo.

1 *ANtimonium crudum*, eſt Minera a terreis et lapideis recrementis Eliquatione purgata, ſtriis nitentibu- tanquam aciculis ordinatim ferè diſpoſitis diſtinctum, atque ex Sulphure et parte metallica, quæ *Regulus antimonii* appellatur, paribus plerumque quantitatibus conflatum.

2 Antimonium crudum, igne mitiori uſtulatum, album copioſè emittit fumum; quem *Florum* nomine colligere licet. Reſiduum gradatim mutatur in Calcem cineream; quæ, igne fortiori fuſa, vitrum facit hyacinthini aut fulvi coloris, durum, volatile, eò pellucidius quò perfectior fuerat Calcinatio et tenuior Liquefactio.

3 Vitrum antimonii, cum aqua regia digeſtum, colorem ei rubeſcentem impertit: Acidis vegetabilium aut Vinis infuſum, abraſione quadam ſuæ ſubſtantiæ vim ipſis emeticam conciliat; quæ

quæ tamen repetitis infusionibus languescere quidem et exhauriri dicitur.

4 Vitrum Antimonii, vel Antimonium crudum, tum lapides tum metallica omnia corpora (Auro et Platina exceptis) fusione dissolvit, et volatilia reddit: et hinc a quibusdam vocatur *Lupus vorax*, *Balneum Solis*, &c.

5 Vitrum vel Calx Antimonii, cum Carbone, Sapone, aliâve substantiâ Phlogiston continente fusa, reducitur in Regulum; qui, si partium debita fiat refrigeratio, stellæ speciem in superficie plerumque exhibet.

6 Regulus Antimonii est Semi-metallum durum admodum et fragile, quod a Zinco et Bismutho tum specie externâ (quâ nec cærulescit, ut Zincum, nec flavescit, ut Bismuthum) tum fusilitate difficiliori distinguitur.

7 Regulus Antimonii, in igne aperto mitiori, fatiscit in Calcem vitrescentem; at in vasis clausis, valido igne fusus, prorsus volatilis est; et Flores exhibet spiculorum splendentium instar, aqua ægriùs solubiles, igne vix volatiles, et in Regulum difficillimè reducendos.

8 *Regulus Antimonii confici potest*, vel

 Calcis

Calcis reductione, ut in propositione 5ª explicatum est; vel Præcipitatione sicca, qua nimirum interventu alterius corporis sulphur a parte regulina separatur; vel solutione humida partis metallicæ Antimonii crudi in Aqua Regia facta et Calcis inde dejiciendæ reductione.

9 Regulus Antimonii, cum Ferro, Stanno et Zinco fusus, mixturas metallicas constituit quæ minorem habent gravitatem specificam; cum Argento, Cupro, Plumbo, et Bismutho, quæ majorem quam secundum regulas communes habere debent.

10 Reguli Antimonii cum acido nitri concocti aliquid dissolvitur, at maxima ex parte in pulverem album corroditur: si cum Acido vitriolico distilletur corroditur quoque; Acidum autem fit sulphureum, et Sulphur sæpe sublimatur. In Acido marino difficulter solvitur, facillime in Aqua Regia.

11 Si Regulus Antimonii, vel Antimonium crudum, cum sublimato mercurii corrosivo trituratione probè misceatur et distilletur, Acidum mari-

num in ſublimato Mercurium deſerens, Regulo Antimonii ſeſe adjunget, et cum eo elevabitur, et in Excipulum tranſibit, vel collo Retortæ, pinguedinis glacialis aut Butyri ſpecie, adhærebit: unde *Butyrum Antimonii* nuncupatur. Aucto deinde igne, Mercurius vivus puriſſimus aſcendet, et in Recipiens decurret. Denique, ſi Antimonium crudum adhibeatur, Cinnabaris ſublimata in collo Retortæ invenietur.

12 Butyrum Antimonii aëre deliqueſcit, et pulverem album deponit: repetitis diſtillationibus fit ex parte fluidum, et olei inſtar limpidum; ex parte, ſi rectè inſtituatur diſtillatio, ſublimatur cryſtallorum forma, in aëre volatilium admodùm et deliqueſcentium.

13 Butyrum Antimonii, aquam affundendo, lacteſcit; et ob Acidum debilitatum, vel propterea quod Sales perfectè medii aqua vix ſunt ſolúbiles, Regulus Antimonii in eo ſolutus maxima ex parte ad imum ſubſidet, ſpecie pulveris albi; qui, cum aqua ſæpius abluatur, inſipidus fiet; et vocatur

Pulvis Algaroth, vel (improprie licet' cum nihil insit Mercurii) *Mercurius vitæ*; qui, si fusus sit, vitrum succinei coloris evadet.

14 Liquor post pulveris Algaroth præcipitationem remanens Butyri aliquid in se retinet soluti, quod evaporatione crystallos, distillatione salem sublimatum in collo retortæ exhibet, aëre non deliquescentem, spiritu vini solubilem, sali sedativo haud absimilem. Ipse liquor, sed nullo jure, nuncupatur *Spiritus vitrioli philosophicus*.

15 Si acidum nitri a Butyro Antimonii distillatione separetur, Aqua Regia nonnullis forsan Reguli partibus inquinata obtinebitur, quæ vulgò dicitur *Spiritus Nitri bezoardicus*, a massa residua novi spiritus nitri abstractione subsequente calcinatione et ablutione conficitur pulvis; qui dicitur *Bezoardicum minerale*.

16 Sal Alkali fixum tùm coctione tùm fusione ex Antimonio crudo sulphur ejus extrahit, et sic *Hepar Sulphuris* constituit; quod partem regulinam Antimonii statim dissolvens hepar efficit Antimonii, colore hepatico vario, et aqua copiosius

aut

aut parcius ſolubile, pro diverſis proportionibus quibus Alkali fixum et Antimonium unà admiſceantur. Ex Hepate Antimonii Pharmaceutici parant medicamentum quod vocant *Crocum metallorum*, nec non *Vinum antimoniale*, *Tartarum emeticum*, &c.

17 Sulphur, quod ab Hepate Antimonii aqua ſoluto per Acetum aut Acidum quodcunque præcipitetur, *Sulphur Antimonii auratum* nuncupatur. Quod vero ſpontanea præcipitatione, dum frigeſcit ſolutio, dejicitur, *Kermes mineralis* aut *Pulvis Carthuſianorum* vocatur: Utrumque a ſulphure communi diſcrepat portione Reguli Antimonii quæ in eo continetur; a ſe invicem vero diſtinguuntur, tùm proportione partis regulinæ ad partem ſulphuream, quæ minor eſt in pulvere Carthuſianorum quàm in ſulphure aurato tùm quòd Kermes mineralis alkali aliquid fixi ſibi adjunctum retinet.

18 Si Antimonium crudum nitro commiſceatur et deflagretur, maſſa reſidua, diverſis coloribus inſignis, diverſis medendi viribus valet; atque *Crocus Antimonii medicinalis* aut *Crocus*

Antimonii mitior, *Antimonii Calx diaphoretica*, &c. nominatur; pro variis proportionibus quibus Nitrum et Antimonium inter se misceantur. Si ea quantitas Nitri adhibeatur quæ toti Sulphuris Antimonii deflagratione destruendo satis sit, vis maxima emetica massæ residuæ comparabitur: sin minori aut majori proportione admisceantur, tum aut totum Sulphuris non erit absumptum, aut pars etiam Reguli Phlogisto suo privabitur. Utroque modo mitius fit medicamentum; quippe quòd vel ad Antimonii crudi, vel ad Calcis metallicæ, vires accedat.

19 Regulus Antimonii cum Sulphure liquatus in massam striatam crudo Antimonio similem frigore concrescet.

C A P. V.

De Bismutho.

1 BISMUTHUM est Semi-metallum cæteris Metallicis Substantiis (Stanno excepto) minore ignis gradu fusile; inter Semi-metalla (Nickel excepto)

excepto) fixissimum; ponderosum, fragile, ab aëre et aqua vix immutandum; Auri instar purum, non mineralisatum, semper repertum.

2 Bismuthum, in valido igne fusum, fumum exspirat inflammabilem: et, vel per se, vel cum additione, sublimari potest in Flores flavescentes: In aperto et mitiori igne, mutatur facillimè in Calcem cineream; quæ continuata flammæ reverberatione flavescit, at vix nisi dum calida restat, rubescet. Calx in Vitrum liquescit, pellucidum, fuscum, terrarum vitrificationi et usibus docimasticis apprimè accommodatum.

3 Acidum Nitri Bismuthum dissolvit magnâ cum Effervescentia et vaporum eructatione. Solutio, evaporata, præbet crystallos albas: affusione aquæ puræ, Bismuthum partim in ea suspenditur; partim ab ea dejicitur; et pulvis sic dejectus vocatur *Magisterium Bismuthi*, *Blanc d'Espagne*, vel *Blanc des perles*.

4 Acidum Salis marini, cum Bismutho coctum, parum ejusdem dissolvit: Acidum Vitrioli nihil, quod præcipitari potest; at colorem rubescentem ab eo extrahit.

5 Si Acidum Vitrioli in Bismuthum fusum infundatur, vel ab eo abstrahatur, sulphuris aliquid colore fusco sublimatur, et odor arsenici sentitur.

6 Acida Vegetabilia aliquid Bismuthi, quod ab Alkali præcipitari potest, coctione dissolvunt. Alkalia fixa Phlogisto imbuta, et alkalia volatilia, in Bismuthum eodem fere modo, quo in Argentum, agunt.

7 Bismuthum, cum Sulphure fusum, cum eo coit et massam efformat striatam, Antimonio crudo quodammodo similem, et facile liquescentem.

8 Bismuthum cum omnibus Metallicis Substantiis (Zinco et Nickel exceptis) sese fusione commiscet et fluxiliora reddit: Stannum dealbat, durius, magis sonorum, et fragilius simul efficiens.

9 Mercurius et Bismuthum, paribus ponderibus unà fusa, Amalgama solidum constituunt. Idem dici potest de Mercurio et Plumbo. At Mercurius, Plumbum, et Bismuthum, paribus ponderibus, Amalgama efformant fluidum: ab hoc Bismuthum, sub specie pulveris gryséi, brevi separatur; at Plumbum

adeò

adeò tenuiter ſolutum reſtat, ut per Corium unà cum Mercurio tranſeat.

10 Aqua ebullit gradu caloris, in Thermometro Fahrenheitiano, 212°. Biſmuthum liqueſcit gradu 460°. Stannum liqueſcit gradu 410°. At Mixtura, ex paribus quantitatibus ſtanni et biſmuthi conflata, liqueſcit gradu 280°.

11 Si Plumbum, Stannum, et Biſmuthum unà fundantur paribus ponderibus, Maſſa mixta minori dicitur liqueſcere ignis gradu quàm eo quo aqua ebullit.

C A P. VI.

De Zinco et Lapide Calaminari.

1 LAPIS *Calaminaris* tertiam vel majorem ponderis ſui partem, Florum ſpecie nec ſulphur nec arſenicum redolentium, uſtulatione amittit. Si cum pulvere carbonum permiſceatur, et igne vehementiſſimo vaſis quantùm fieri poterit clauſis diſtilletur, Subſtantiam præbebit Metallicam, ex cæruleo albam; quæ *Zincum* appellatur.

2 *Zincum*

2 *Zincum* eſt Semi-metallum: vel ſtriatum, ut Zincum Goſlarienſe; vel teſſellis diſtinctum, ut Indicum et Anglicanum; durum; ſonorum, malleo (dum frigidum eſt) aliquantum cedens; in pulverem trituratione non reducendum; in igne liqueſcens ſimul ac rubet, at Plumbo difficilius: ſæpius fuſum, fit (Stanni inſtar) durius, fragilius, minùs fuſile, et calcinationi minus obnoxium: ab aëre et aqua non multùm mutatur.

3 Zincum, igne leniori fuſum, mutatur in Calcem: at ſi violentior ſit ignis, inflammatur cum ſtrepitu, et odorem emittit arſenicalem; flamma lucidiſſima, viridis, ne minima fuligine inquinata, durat donec tota Zinci maſſa ſit combuſta et in Flores albos, leviſſimos, Goſſypio ſimiles, (quos *Lanam* nuncupant *Philoſophicam*) ſublimata.

4 Zinci Flores ab Acidis omnibus diſſolvuntur; Phlogiſti additione, in vaſis clauſis *reducuntur*; in igne fixi reſtant, et in vitrum coloris praſini tandem convertuntur.

5 Acida omnia mineralia, nec non Acetum faciliori negotio Zincum quàm

cætera

cætera Metallica Corpora diſſolvunt: Si cum Oleo Vitrioli diſtilletur Sulphur ſublimatur, Reſiduum Arſenicum olet.

6 Zincum dum, ab Acido vitriolico aquoſo, vel ab Acido marino concentrato, diſſolvitur, Aërem, vel vaporem elaſticum, fœtidum, inflammabilem copiosè emittit; at nihil Sulphuris præbet.

7 Pondus totum Aëris inflammabilis, qui per ſolutionem Zinci in Acido vitriolico generatur, æquale circiter deprehenditur parti viceſimæ-quartæ ponderis ipſius Zinci.

8 Denſitas aëris inflammabilis ferè eadem eſt ex qualicunque metallo, vel qualicunque Acido ſit genitus.

9 Aër inflammabilis, per ſolutionem Zinci generatus, levior eſt aëre communi (Thermometro denotante gradum 50 et Barometro 30 uncias) in proportione circiter 11 : 1.

10 Zincum in Acido vitriolico ſolutum, evaporatione concreſcit in Cryſtallos, quæ vocantur *Vitriolum Album* vel *Goſlarienſe*.

11 Zincum cum omnibus Metallicis Subſtantiis (Biſmutho excepto) fuſione

uniri

uniri poteſt. Paullò difficilius coit cum Ferro; facilius cum Cupro; cum reliquis facillime.

12 Zincum ab omnibus Metallicis Corporibus diſtinguitur; et ab iis depurgari poteſt: eò quòd cum Sulphure aut Hepate Sulphuris colliquefactum, nullam ab iis mutationem patitur.

C A P. VII.

De Cobalto et ejus Regulo.

1 SI Cobaltum uſtulatione in furno reverberii ab arſenico liberetur, in pulverem poſtea redigatur, et cum duplo vel triplo arenæ aut ſilicum calcinatorum et contuſorum miſceatur, mixtura aquâ irrorata in maſſam quaſi lapideam brevi indureſcit, et *Zaffera* vocatur.

2 Omnia Acida mineralia Zafferæ venalis aliquid diſſolvunt; acida vitrioli et nitri colorem fulvum aut roſeum ab ea extrahunt qui calore non mutatur; cum ab acido marino facta eſt ſolutio, color ejus, dum frigida manet, eſt fulvus

aut intensè viridis prout acidum est aquâ dilutum necne; at dum calescit solutio fulvus mutatur in viridem.

3 Zaffera in acido vitriolico soluta, forma pulveris cærulei præcipitatur ab alkali fixo phlogisto imbuto; si uberior alkali copia adhibeatur, præcipitatum fit e cæruleo gryseum, quod tamen affusione spiritus salis colorem cæruleum recuperat prorsus, uti evenire solet cùm cæruleum Berolinense a solutione vitrioli viridis dejicitur.

4 Zaffera in acido vitriolico soluta gallarum decocto affundendo nigrescit.

5 Zaffera ab acido quovis præcipitata, cum oleo aut sevo mista et igne leniter calcinata, fit pulvis niger qui magneti obsequitur.

6 Zaffera igne liquescit in vitrum cæruleum, quod cùm in pollinem subtilissimum reducitur vocatur *Smaltum* vel *Encaustum cæruleum*.

7 Si Zaffera aut Smaltum cum substantia inflammabili unà fundantur, odor arsenicalis sentitur, et substantia metallica in fundum præcipitatur quæ dicitur *Regulus Cobalti*.

8 Regulus Cobalti a reductione Zafferæ

feræ ab acidis præcipitatæ vel ſmalti proveniens eſt fragilis admodum et durus, coloris gryſei, texturæ lævis at non granulatæ; a magnete promptiſſimè attrahitur, calcinatione mutatur in pulverem nigrum qui ab igne vehementiori in vitrum cæruleum, ferri inſtar, liqueſcit.

9 In Regulum Cobalti, acida vitrioli et ſalis marini vix agunt; ſolutio in acido nitri facta eſt rubra, in aqua regia viridis.

10 Regulus Cobalti per Alkali fixum commune ab aqua regia præcipitatur in pulverem rubeſcentem, per Alkali phlogiſto imbutum in pulverem cæruleum.

C A P. VIII.

De Nickel.

1 NICKEL eſt Semi-metallum ex gryſeo rubens, cæteris minus fuſile, in calcem viridem mutabile, quæ in igne etiam fortiſſimo vix liqueſcet in vitrum.

2 Si

2 Si Nickel et Bismuthum unà funduntur et sub fusione admisceantur, Nickel conjunctionem cum Bismutho, prorsus aufugiens semper supernatat, et Bismuthum in imum subsidet.

3 Acidum vitriolicum, sive concentratum sit sive aqua dilutum, Nickel non dissolvit: Acidum marinum paullo segnius in illud agit; Acidum nitri cum fumorum rubrorum eructatione violenter dissolvit, solutio viret, et ab Alkali volatilis affusione fit cærulea.

4 Dum Nickel ab acido nitri dissolvitur, flocculi gryséi ab eo separantur, qui in igne et sulphuris et arsenici dant indicia.

5 Nickel ab acido nitri per alkali fixum præcipitatur in pulverem subviridem.

C A P. IX.

De Plumbo sive Saturno.

1 PLumbum est Metallum imperfectum, minus quam cætera durum, elasticum, tenax, et sonorum;

Stanno minus fusile: ab actione aeris et aquæ rubiginem quandam gryseam contrahit, at difficiliùs corroditur quam Ferrum.

2 Filum Plumbi cylindricum cujus diameter decimæ parti unciæ æqualis est sustinere potest pondus 29¼ Librarum.

3 Plumbum in igne fluit antequam candescit; aucto calore effumat et ebullit; fusum in superficie tegitur pelliculâ cinereà versicolore; quâ semotâ vel cum plumbo mixtâ, altera enascitur; et sic tandem tota massa in Calcem converti potest quæ vocatur *Plumbum ustum.* Hoc autem, Plumbo in hunc finem adhibito, levius est.

4 Plumbum ustum, si subitam ignis violenti actionem patiatur, fit Olei instar fluidum, et in Scoriam convertitur vitrescentem, ex squamosis lamellis, flavescentibus aut rubescentibus, pro diverso ignis gradu, constantem, et *Lithargyrus* vocatur. Lithargyrus æquè ac Plumbum ustum in igne mitiori diutiùs detentus, flammâ simul in superficiem ejus supernè reverberatâ, fit primò flavus, deinde aureus et Gallico

 idiomate

idiomate a Pictoribus dicitur *Massicot* ; tandem ruber, et vocatur *Minium*.

5 Massicot in igne calefactus fit e flavo ruber, frigescens iterum fit flavus.

6 Plumbum in Minium conversum, licèt multum de substantiâ suâ Florum formâ deperdat, pondere plusquam decimâ parte augetur ; at Minium illud nihilominùs, *Reductione factâ*, pondus æquale ponderi Plumbi ex quo erat confectum minimè præbebit.

7 Lithargyrus, Massicot, Minium, aliæve Plumbi Calces, facilè liquescunt in Vitrum coloris aurei.

8 Lithargyrus vel Vitrum Plumbi cum lapidibus, vel terris quibuscunque refractariis fusus, mirificè earum liquefactionem promovet ; et Metallica corpora (Auro, Platinâ et Argento exceptis) in Scoriam vel Vitrum secum rapit : et hinc commodè adhibetur tùm ad Vitra conficienda pellucidissima tùm ad Metalla perfecta a Mineris et Metallicis imperfectis purganda.

9 Plumbum ab Acido Nitri aquâ diluto copiosè dissolvitur. Solutio evaporata in Crystallos concrescit, albus, pyramidales, sapore dulces, austeras ;

 quæ

quæ in vaſe clauſo igni expoſitæ crepitant at non inflammantur.

10 Plumbum in Acido Nitri ſolutum, inde præcipitatur ab Acidis tum Vitrioli tum Salis marini quibus ſeſe conjunget: cum Acido marino ſic conjunctum Plumbum quod corneum vocant, cum Acido Vitrioli, Vitriolum Plumbi conſtituit.

11 Si Plumbum ſit cum Acido Vitriolico concoctum aliquanta ex parte diſſolvitur; Diſtillatione in vaſis clauſis inſtitutâ, totum corroditur in maſſam albam aquâ ex parte ſolubilem; vapor Sulphureus, qui inflammationem nonnunquam admittit, ſub fine exit, et Sulphur ſimul ſublimatur.

12 Si in Plumbum fuſum Acidum Vitriolicum infundatur, Sulphur communi prorſus ſimile ſtatim ſublimatur.

13 Si Plumbum ſit cum Acido marino coctum, exigua ejus pars ab Acido diſſolvitur. Solutio, debitâ factâ evaporatione, Cryſtallos ſiſtit, albas, pellucidas, Nitro haud abſimiles; vel cum adhuc calida ſit in aquam frigidam infuſa, præcipitatum præbet eximie album.

14 Acetum

14 Acetum longâ digestione parum Plumbi dissolvit; at in vapores resolutum illud rodit in rubiginem squamosam, friabilem, insipidam, inodoram, quæ vocatur *Cerusa alba*.

15 Cerusa alba, vel Lithargyrus vel Minium si cum Aceto coquatur ab eo dissolvitur. Quælibet harum solutionum usque ad Mellis ferè crassitiem evaporata, Salem præbet crystallinum, dulcem, stipticum, venenosum dictum *Saccharum Saturni*, quod distillatione spiritum ardentem præbet.

16 Olea Vegetabilium sive stillatitia sive pressa Plumbum integrum vel Calces ejus quaslibet (copiosiùs autem Minium) in coctione dissolvunt. Solutiones ab Aceto possunt decomponi: et Olea pressa sic a Plumbo liberata Spiritu Vini fiunt solubilia.

17 Alkalia fixa per Calcem vivam acuata, parum Plumbi dissolvunt, multum rodunt.

18 Si Calx quælibet Plumbi vel Plumbum integrum cùm Sulphure liquefiat, in Mineram, igne vix fusibilem, at naturali Plumbi Mineræ specie persimilem mutabitur. Plumbum cum

Arſenico fuſum in Flores partim ſublimatur, partim in Vitrum hyacinthinum mutatur.

19 Plumbum, cum omnibus ſubſtantiis Metallicis (Ferro excepto), per fuſionem commiſceri poteſt.

20 Si Mixtura Metallica ex Plumbo et Stanno confecta ſit fuſa cum ferro, Stannum (connubium Plumbi reſpuens) ſeſe Ferro adjunget.

21 Si Mixtura Metallica ex Ferro et Cupro vel ex Ferro et Argento conflata, ſit fuſa cum Plumbo, Cuprum vel Argentum Ferrum deſeret, et cum Plumbo in maſſam coibit.

22 Si Mixtura Metallica ex Plumbo et Stanno confecta ſit fuſa cum mixturâ ex Ferro et Argento conflatâ Stannum (Plumbum deſerens) ſeſe Ferro adjunget; et Plumbum ſimul Argenti connubium petit, et maſſas (utcunque ſub fuſione agitantur) diſtinctas, cum frigeſcunt, ſemper exhibebunt.

23 Plumbum ſcriptorium ſive Molibdæna, igne violentiſſimo occluſo, ferè nihil; igne aperto decimam quartam partem ponderis amittit. Reſiduum

duum ne particulam præbet Plumbi at Ferri Magneti obedientis multum.

24 Plumbum ſcriptorium, in pollinem comminutum, cum Sulphure liquato intime coit, et maſſam vix a verâ Minerâ diſtinguendam conſtituit; niſi quòd in flammâ candelæ accenditur et fumum Sulphureum exſpirat.

CAP. X.

De Cupro ſive Venere.

1 CUPRUM eſt Metallum imperfectum; Auro, Argento, Plumbo et Stanno magis durum et elaſticum, at in igne minus fuſile; Plumbo et Stanno magis ductile et fixum: et omnium maximè ſonorum.

2 Cuprum, diu candeſcens, tandem fluit; fuſum, fit humidi admodum impatiens; in aperto igne violentiori ſi detineatur, Pondus ejus diminuitur, Superficies comburitur et in Crocum ſubrubrum convertitur, qui ab igne ſolari denſato vitrum fit rubrum.

3 Ea eſt *Cupri tenacitas* ut filum

 cylin-

cylindricum, cujus diameter æqualis est decimæ parti unciæ, sustineat pondo 299¼.

4 Cuprum ab omnibus Acidis, tùm mineralibus tùm vegetabilibus, dissolvitur, nec non ab Alkali fixo et volatili, a Salibus mediis, Oleis expressis et essentialibus; ab ipsis Aere et Aquâ eroditur et in Æruginem mutatur: *frictu calefactum, odorem*; manducatum, saporem nauseam moventem præbet.

5 Cuprum ab Acido Nitri facillimè dissolvitur; ab Acido marino difficiliùs, ab Acido vitriolico difficillimè, nisi acidum sit concentratum et ebulliens. Hæc Solutio crystallos dat cæruleas, figura rhomboidales, in aere non deliquescentes, quæque et *Vitriolum* constituunt quod a Mercatoribus *Romanum* aut *Cyprium*, vel *Cuperosum cæruleum* vocatur.

6 Ab aquis cæmentatoriis ut vocantur, vel, quod eodem redit, a vitriolo cæruleo in aquâ soluto Cuprum purissimum præcipitatur additione ferri. Solutio virescit, acido ferrum subeunte.

7 Si Cupri lamellæ sint alternatìm stratæ cum vinaceis exsiccatis (quæ eum

cum vino generoso per fermentationem in acetum abeunte aliquot dies priùs fuerint digestæ) erodentur, et superficies singularum viridi-cærulea quadam cooperietur efflorescentia, quæ *Ærugo* vel *Viride Æris* nuncupatur.

8 Cuprum vel Viride Æris venale (quod constat ex Cupro et Acido in proportione circiter 5 : 7.) ab aceto stillatitio solutum, dat per inspissationem crystallos virides, aëre sicco in pulverem fatiscentes, quæ apud Mercatores impropriè dicuntur *Viride Æris distillatum*.

9 Viride Æris distillatum, dimidium penè sui ponderis, Acidi admodum concentrati distillatione præbet, quod *Acetum radicatum* vel *Spiritus Veneris* vocatur.

10 Spiritus Veneris est aliquantùm volatilis, odorem exhalat suffocantem; igne Spiritus quemadmodum Vini est inflammabilis; crystallisationem admittit; et *Ætherem acetosum* distillatione cum Spiritu Vini exhibet.

11 Residuum ex Spiritu Veneris præparatione in Cuprum reducitur per simplicem cum Borace fusionem.

12 Si Cupri limatura et Sublimatum

Mercuri

Mercurii corrosivum unà distillentur, Acidum marinum Cuprum invadens, illud in massam resinæ citrinæ vel rubræ similem mutabit.

13 Cuprum ab Oleis vel Spiritu Vini solutum, vel in integro etiam suo statu igne utcunque combustum, colorem viridem flammæ impertit.

14 Cuprum calcinatum, præcipitatum, sulphuratum, qualicunque demum modo paratum, vel etiam integrum vitro mistum et sine additione fusum, colore viridi vitrum imbuit.

15 Si Cuprum sit cum Lapide Calaminari aliâve Zinci Minerâ, debitâ adhibitâ encheiresi colliquefactum, pondere, ad tertiam vel majorem ponderis totius partem, augebitur. Mixtura Metallica flava conflabitur, quæ *Aurichalcum* vocatur.

16 Aurichalcum frigescens Cupri malleabilitatem habet; igne calefactum fit fragile; sed levius, durius, fusilius, magis sonorum, scorificationi in igne mitiori, actioni aëris et aquæ ipso Cupro minus obnoxium deprehenditur.

17 Aurichalcum in igne diutius fusum mutatur in Cuprum; quippe Zincum

eum five pars metallica Lapidis Calaminaris comburendo diffipatur.

18 Aurichalcum, cum Mercurio trituratione amalgamatum, mutatur in Zincum; quippe Cuprum, reftante Zinco, Mercurio adjungitur.

19 Cuprum, cum Zinco liquatum in proportione 4 : 1. vel fecundum alias proportiones, Mixturas varias Metallicas conftituit, colore Auro perquam fimiles, at propter Zinci impuritatem plerumque fragiles; quæ vocantur *Metalla Principis Ruperti*, *Metalla aurea fophiftica*, *Metalla Tombacina*, &c.

20 *Cuprum album* conficitur ex Cupro colliquefacto cum Arfenico per Nitrum fixo. Sæpiùs fufum pondere diminuitur parte circitèr feptimâ, in Cuprum rubrum mutatur, et fub fufione odorem efflat arfenicalem.

21 Si Cuprum et Stannum, quibus pauxillum Aurichalci aut Bifmuthi nonnunquam adjicitur, per fufionem commifceantur, Mixturam Metallicam conftituent fubflavam, duram, fonoram, fragilem, Aeris et Aquæ actioni ipfo Cupro longe difficilius cedentem; quæ vocatur *Metallum tormentorum bellicorum*,

rum, *Campanarum*, *Æs Caldarium*, *Bronze*, &c. pro varia proportione quibus Cuprum et Stannum unà liquantur.

22 Si æquales magnitudines Cupri et Stanni unà fundantur, Mixtura ex his conflata minor erit, parte plusquam quarta, quam cuprum et stannum simul sumpta; pondus tamen haud mutabitur, et gravitas specifica fiet ipsâ Cupri gravitate specificâ major.

CAP. XI.

De Ferro sive Marte.

1 *FERRUM* est Metallum imperfectissimum; aëri et aquæ expositum, omnium facillimè rubigine exeditur; cæteris (Platinâ exceptâ) minùs fusile, et (excepto Cupro) magis sonorum; duritie et elasticitate omnia exsuperat; et unicum est quod a Magnete attrahitur.

2 Ferri Filum cylindricum, cujus Diameter decimæ parti unciæ æqualis est, sustinere potest pondus 450 Librarum. Hinc Ferrum videtur omnium Metal-

Metallorum esse tenacissimum. Nam tenacitas non videtur esse mensuranda ponderibus quibus disrumpantur fila metallica earumdem Diametrorum, ut assolet, sed quibus cohæsio datarum Quantitatum materiæ superatur; vel ponderibus, quibus fila, cujus Diametri sunt in reciprocâ subduplicatâ ratione gravitatum specificarum, disrumpuntur.

3 Ferrum, violentiori motu attritum, candescit; igni fortiori expositum, in superficie quodammodo vitrescit; ad fusionem accedens scintillat, fumum vel flammam quasi Sulphuream emittit, et in calcem mutatur: at in clauso vase Calcinationem non patitur.

4 Si Ferrum excandescens follium continuo flatu urgeatur, Calor ejus augebitur et liquescet.

5 Ferrum ab Acido vitriolico aquoso facillimè dissolvitur. Solutio hæc evaporata Salem præbet, viridem, rhomboidalem, qui vocatur *Sal Martis*, *vitriolum* vel *Cuperosum viride*.

6 Ferrum durissimum, sub aqua vitriolica per plures Annos submersum, fit, ut dicitur, mollitie et Colore Molibdenæ persimile.

7 Acidum

7 Acidum nitrosum agit violentèr in Ferrum; marinum paullò segniùs; utrumque cum eo Salem deliquescentem efficit; qui, cùm Acidum marinum adhibetur, in Spiritu Vini est maximâ ex parte solubilis.

8 Acida omnia Vegetabilia, tùm nativa tùm fermentatione generata, nec non Sal Ammoniacus, Sales Alkalini, Aqua, et Aer, agunt in Ferrum et varia inde Pharmaceuticis suppeditantur medicamenta. Horum præcipua sunt 1° *Croci martiales* vel *Calces Ferri*, colore rubro aut flavescente tinctæ, sive parantur Calcinatione, Præcipitatione, vel simplici Actione Aquæ, vel Aquæ et Aeris conjuncta. 2° *Tincturæ martiales*, vel Ferrum variis modis in Spiritu Vini solutum. 3° *Flores martiales*, vel Ferrum cum Sale Ammoniaco sublimatum. 4° *Lixivium Martis*, vel Residuum a Sublimatione Ferri cum Sale Ammoniaco quod in liquorem deliquio redactum est. 5° *Vinum Chalybeatum*, vel Ferrum in vino Rhenano digestione solutum. 6° *Rotuli martiales*, et *Tartarus Chalybeatus*, vel Ferrum cum Tartaro conjunctum, &c.

9 Limatura ferri aquâ madefacta sæpius et exsiccata, in Rubiginem tota convertitur, pondere augetur, et *Salem volatilem*, ut dicitur, distillatione exhibet.

10 Cum Ferrum in acido vitriolico vel marino dissolvitur, vapor elasticus, fœtens, sulphureus generatur; qui admotione Candelæ inflammatur.

11 Si partes æquales Scobis ferreæ et Sulphuris vulgaris in mortario triturentur, et in pastam aqua formentur, Mixtura, paucis elapsis horis, incalescit, turgescit, vaporem sulphureum expirat, et si quantitas sit satis magna, flammam sponte concipit.

12 Ferrum candens cum Sulphure facillimè coit, et ab eo reducitur in Speciem Mineræ aere efflorescentis, Pyritæ martiali efflorescenti persimilis.

13 Ferrum, uberiori Phlogisto imbutum, mutatur in *Chalybem*.

14 Chalybs, Phlogisto superabundanti privatus, mutatur in ferrum. Quær. Utrum Phlogiston sit unicum Principium, ex cujus majore vel minore copiâ pendet inter Ferrum et Chalybem discrimen?

15 Chalybs,

15 Chalybs, igne calefactus et aqua frigida subitò immersus, fit durus admodum et fragilis; et sic a ferro distinguitur, æquè ac majori suâ gravitate specificâ, fusilitate in igne faciliore, elasticitate majori, Colore magis nigricante, et textura magis compacta, quæ ex granis exiguis, diversarum in diversis Generibus magnitudinum constat.

16 Chalybs expolitus, per diversam ignis actionem, diversos exhibet Colores. Primò flavescit, deinde flavet, rubescit, purpurascit, livescit, nigrescit, tandem aucto adhuc igne candescit.

17 Chalbys, igne candefactus, et immersione in aquam induratus, duritiem suam gradatim amittit dum colores diversos prædictos suscipit; et ex hac coloris mutatione de duritie instrumentorum quæ singulis operibus conveniat judicium ferunt opifices.

18 Ferrum in Acidis solutum adfusione decocti Gallarum (si solutio saturetur) nigrescit, et lente in fundum subsidet, specie nigri pulveris; qui ab acido maximâ ex parte iterum dissolvi potest.

19 Ferrum in Acido vitriolico solu-

tum,

tum, inde præcipitari poteſt Alkali fixo quod phlogiſto qualicumque ſaturetur idque ſub formâ pulveris cærulei; qui a pictoribus nuncupatur *Cæruleum Bærolinenſe.*

20 In Cæruleum Bærolinenſe Acida non agunt: Alkalia fixa materiam colorantem ab eo extrahunt, et eâ ſaturari poſſint.

21 Alkalia fixa, cum Materia colorante Cærulei Bærolinenſis ſaturata, cum Acidis non effervefcunt; colorem Cæruleum Vegetabilium non virideſcunt; et Ferrum, in Acido quocunque ſolutum, ſub cæruleo colore præcipitant.

22 In omni ferè Arenâ, in Argillis coloratis, in Lapide Lazuli, in pleriſque lapidibus pretioſis, in cunctorum ferè Vegetabilium cineribus, in Craſſamento ſanguinis, in Urinâ, et in carne Animalium, in cineres redactis, vel etiam leni calore exſiccatis, particulæ plurimæ reperiuntur quæ a Magnete attrahuntur.

23 In Oſſibus Animalium, in pinguedine, et parte ſanguinis feroſâ, calcinatis, vel nullæ vel perpaucæ depre-

henduntur particulæ Magneti obſequentes.

24 Particulæ quæ Magnetis Vim patiuntur plures reperiuntur in ſanguine Hominum et Quadrupedum, quàm in Sanguine Piſcium; et plures in Sanguine Piſcium quàm Volatilium: et, in genere, quò uberior ſit Globulorum rubrorum in ſanguine innatantium copia, eò major deprehenditur quantitas particularum, Magnetis actioni obedientium.

25 Particulæ, a cineribus magnete ſeparatæ, Acidis diſſolvi nequeunt.

26 Ferrum, cum Plumbo fuſum, omne cum eo reſpuit conſortium, et ei perpetuo ſupernatat: at aliis Metallicis Subſtantiis (Zinco forſan, quod calorem debitum ſuſtinere nequeat, excepto) facile per fuſionem coit, et Mixturas varias Metallicas conſtituit: Hæ autem, ſi ejus cum Regulo Antimonii (ob Sulphur forſan, quo Regulus inquinatur) mixturam excipias, Magnetis attractionem patiuntur.

27 Ferrum cum Mercurio vix amalgamari poteſt, at ſub eo nihilominus per aliquot Dies ſubmerſum, vel vapori

pori Mercuriali expositum fit, ut dicitur, fragile et friabile.

28 Ferrum materia vitrescente per fusionem mixtum, minore ignis gradu viridem, majore cæruleum ei semper impertit colorem.

CAP. XII.

De Stanno, sive Jove.

1 STANNUM est metallum imperfectum, præ cæteris metallis levius et in igne fusilius; at, Plumbo excepto, minima duritie, tenacitate, elasticitate, sono gaudens: Stridor quidam inter plicandum, ei, Zincum si excipias, est proprius; aëris et aquæ actioni parum profecto cedit.

2 Stanni filum cylindricum, cujus diameter decimæ parti unciæ æqualis est, sustinere potest pondus 49 Librarum.

3 Stannum usque ferè ad fusionem calefactum, vel post fusionem frigescens et in solidum tantum non condensatum, fit rigidum admodum et fragile, et si motu velociori in eo statu

ſtatu conquaſſetur in granula minuta, poroſa erit divulſum. Plumbum et Aurichalcum ſimilem ſubeant comminutionem, at Aurum et Argentum quæ fuſioni proxima fiunt tenaciora, Granulationem ea methodo non admittunt.

4 Stannum fuſum odorem exſpirat arſenicalem, ſcintillas emittit, et in calcem albeſcentem, difficillimè reducendam, et in foco etiam ſpeculi uſtorii vix vitrificandam, citò calcinatur.

5 Stannum in igne fortiſſimo diutius detentum dicitur partim in flores ſublimari, partim in calcem rubeſcentem redigi, partim in vitrum pellucidum coloris rubei mutari.

6 Stannum et Plumbum una fuſa turgeſcunt, et lucida quaſi combuſtione citius in cineres exuruntur, quàm ſingula ſeorſim calcinata.

7 Si Calces ſtanni et plumbi cum ſilice calcinato vel vitro pellucidiſſimo contuſo et ſale alkalino fixo ſimul fundantur, maſſam vitreſcentem lacteam in arte fictili et encauſtica utiliſſimam conſtituent; cui ſi calces aliorum metallorum

tallorum conjungantur, encaufta varia diverfimode colorata conficientur.

8 Si Stannum cum Acido vitriolico concentrato ufque ad ficcitatem in vafis claufis diftilletur, multum exibit vaporis fulphurei qui inflammationem nonnunquam admittit, et fulphur fimul in collo retortæ fublimatum invenietur. Quod fi acidum fit aqua dilutum, vapor eft femper ferè inflammabilis, et fulphur præcedente, ut videtur, minus flavum et in minori copia generatur.

9 Stannum in acido vitriolico aquofo copiosè diffolvitur; folutio, debitâ factâ evaporatione, cryftallos præbet albas, tenues lanugini fimiles, quas *Vitriolum Jovis* nominare liceat.

10 Stannum ab acido marino calefacto et concentrato promptius diffolvitur, et vapor inde inflammabilis fulphur et Arfenicum redolens producitur, cujus pondus æquale circiter deprehenditur parti quadragefimæ quartæ ponderis Stanni foluti.

11 Si Stannum cum Sublimato mercurii corrofivo diftilletur, primo in excipulum cadent guttullæ quædam acidi marini, deinde prodibit liquor eximiè

 fumans,

fumans, qui *Liquor fumans Libavii* dicitur (in æthere marino conficiendo utilissimus), tandem in collum retortæ stannum cum acido marino conjunctum sub forma solida elevabitur.

12 Stannum ab acido nitri promptissimè dissolvitur, vel potius ni cautè instituatur solutio in calcem corroditur: Ab aqua regia solutio ejus facillimè absolvitur; hæc solutio est coloris et spissitudinis variæ, haud rarò in solidum, juris instar gelati, concrescit.

13 Stannum in aqua regia solutum, sub leni evaporatione arsenici plerumque crystallos exhibet: quod ab imperfecta mineræ calcinatione provenire censendum est, cùm datur stannum ab omni arsenico immune.

14 Stannum in acido nitri vel in aqua regia solutum, et cum purpurascentibus decoctionibus Ligni Brasiliani, Cochinellæ, &c. mixtum, colores earum in usus tinctiles eximiè exaltat.

15 Si Stannum, argentum vivum, sulphur, et sal ammoniacus accuratè admisceantur, ac in igne forti sublimentur, superiora vasorum petet quædam

dam Cinnabaris, in imo remanebit massa levis, friabilis, coloris aurei, quæ vocatur *Aurum Musivum* vel *Musicum*, quod phlogisti additione in stannum reducatur.

16 Stannum in Aceto, vino Rhenano, et succis nativis acidis vegetabilium dissolvi potest.

17 Stannum cum omnibus metallicis corporibus facillimè fusione commisceri potest; fragilia (ob arsenicum forsan quo inquinatur) reddit, et difficillimè ab iis separatur.

18 Stannum cum plumbo colliquatum fit rigidius; fusum cum Bismutho, Zinco, Regulo Antimonii, &c. fit magis durum, album, et sonorum.

19 Stannum foliatum cum mercurio facillimè in Amalgama coit, quo superficies posteriores speculorum planorum obduci solent.

20 Si Stannum, Plumbum, et Bismuthum unà fundantur, et cum Mercurio commisceantur, Amalgama constituent ad superficies concavas obtegendas apprimè idoneum.

21 Stannum fusum cupri et ferri non tantum superficiei adhærescit, sed

 in

in intimiora penetrat, ut videre licet in ferreis instrumentis quibus opifices utuntur ad laminas ferreas stanno illinendas.

CAP. XIII.

De Argento, sive Lunâ.

1 *ARgentum* est Metallum perfectum; ductilitate et fixitate Auro proximum; fluit cùm primùm candescit, et paullò facilius quam Ferrum, Cuprum et Aurum: Aurum, Plumbum et Stannum duritie et elasticitate superat; omnibus Metallis (Cupro excepto) magis sonorum est; actione aëris et aquæ prorsus immutabile, at a Sulphureorum halitu infuscatur.

2 Argentum, ut ait Kunckelius, igni vehementissimo furni vitriarii per mensem expositum, 64ª circiter ponderis parte diminutum deprehendebatur; spatio duorum mensium, ut ait Gastus Clavius, decrementum ponderis in eodem igne patiebatur æquale parti duodecimæ ponderis totius; ut ait Hombergius, vitro ustorio expositum in fu-

mum

mum abiit, ſed in Vitrum non fuit converſum.—Annon ponderum decrementa ignobili alicui Metallo quod cum argento miſceatur, potius quàm defectui fixitatis in Argento ipſo, attribui debeant?—Annon fumus, quem obſervavit Hombergius, ipſi Argento in Auras acto, potius quàm Argento in partes diſſimiles reſoluto, referendus eſt?

3 Ea eſt *Argenti tenacitas*, ut filum Cylindricum, cujus diameter æqualis eſt decimæ parti unciæ, ſuſtinere poteſt pondus 270 Librarum.

4 Argentum non ſolvitur in Acido Salis marini, viâ humidâ, nec in Aquâ regiâ; difficillimè quidem in Oleo Vitrioli, etiam ebulliente; promptiſſimè verò in Acido Nitri ſolvitur. Solutio in Acido Nitri facta, ſi depuratum ſit Argentum, eſt pellucida, excolor, amara, cauſtica.

5 Solutio Argenti, in Acido Nitri facta, Capillos, Cutem, Oſſa, cæteraque Animalium ſolida, nec non Achatem, Jaſpidem, pluresque alios lapides fuſco vel nigro colore tingit: evaporatione in Cryſtallos concreſcit albas, quæ in igne fuſæ colorem induunt nigrum,

grum, et massam causticam constituunt quæ vulgò dicitur *Luna Caustica* vel *Lapis infernalis*; quæ vi minori, aut majori, causticâ pollet, prout Solutio est penitus, vel ex parte, saturata.

6 Argentum, ex solutione suâ in Acido Nitri præcipitatum, fit solubile, per Acidum vegetabile, vel nativum, vel ex fermentatione generatum: per Alkali volatile et Alkali fixum, quod conficitur calcinando Sale alkalino fixo, cum sanguine bovino: sed nec per Alkali fixum commune, vel causticum, vel Calcinatione cum Carbone vegetabili paratum, nec per Nitrum fixum detonatione cum carbone vegetabili aut animali. Hoc autem defectui salis alkalini volatilis quo alkali fixum sanguine bovino calcinatum imbuitur, attribui forsan potest.

7 Si in Solutionem Argenti Acido Nitri factam, infundatur Acidum vitrioli, vel Salis marini, vel Solutio cujuslibet Salis, hoc vel illud Acidum continentis, Argentum deserat Acidum Nitri, et cum Acido vitrioli vel Salis marini conjunctum, Coaguli instar albi, in fundum subsidet.

8 Argentum,

8 Argentum, cum Acido marino conjunctum et igne fusum, fit Corpus admodum volatile: ex parte pellucidum et quasi corneum; et exindè *Luna cornea* appellatur: quæ in aquâ vix solvitur, et quintâ circiter parte, accretione Acidi, Argento soluto ponderosior est.

9 Si Argentum sit cum Acido vitriolico usque ad siccitatem distillatum, vapor prodit sulphureus, at nihil sulphuris sublimari observatur; ipsum Argentum in massam duram flavescentem, aquâ maximâ ex parte solubilem, et Crystallisationis capacem convertitur.

10 Si in Argentum fusum Acidum vitriolicum infundatur, vapor prodit eximiè sulphureus; at Sulphur non separatur.

11 Argentum ab omnibus Metallicis Substantiis (Auro et Platinâ, et perparvâ forsan Cupri quantitate exceptis) Cupellatione liberatur. In Acido Nitri solutum, et inde ab Acido marino præcipitatum, fit, reductione factâ, ab omni Corpore heterogeneo immune et purissimum habetur.

12 Argentum,

12 Argentum, cum Sulphure fusum, in Massam fragilem convertitur, colore et mollitie plumbi similem. Hâc fusione minima pars Auri a Massâ quâlibet Argenti separari potest.

13 Argentum, cum Cupro Colliquefactione conjunctum, fit magis durum et sonorum. Quod si cum Stanno vel Regulo Antimonii conjungatur, pene omnem suam Malleabilitatem perdit.

14 Argentum purum ponitur æquale duodecim denariis. Si ejus pars duodecima sit Cuprum, vel aliud imperfectum metallum, dicitur constare ex undecim denariis; quale est Argentum ex quo *Ludovici* cuduntur. Argentum Anglicè dictum *Sterling* constat ex undecim denariis, unà cum decimâ denarii parte; sive Cuprum est ad Argentum ut 3 : 37, in Monetâ nostrâ.

15 Argentum vel sulphuratum, vel præcipitatum, vel integrum, cum Vitro crystallino fusione intimè mixtum, vel Cæmentatione utcunque conjunctum, colorem flavum ei semper impertit.

C A P. XIV.

De Auro, sive Sole.

1 AURUM est Metallum perfectissimum, coloris inter fulvum et subflavum varii; cæteris metallis, plumbo et stanno exceptis, minus elasticum, durum, et sonorum; plumbo, stanno, et argento minus fusile; fixitate, pondere, et ductili extensione omnia exsuperans; actione aëris et aquæ mutabile.

2 Aurum in igne vehementissimo furni vitriarii per plures hebdomadas liquefactum, nullam aut calcinationem aut partium dissipationem patitur: ab igne solari condensato, in auras dissipatur, at nec in vitrum violacei coloris nec in partes dissimiles, ab illo etiam ignis gradu, converti videtur.

3 Aurum in igne candescens funditur, fusum colorem cæruleo-viridem induit, cæteris metallis mole magis augeri videtur; non satis fusum vel subito nimis refrigeratum, fit malleo paullò

paullò intractabilius, at a carbonum vaporibus fragile non redditur.

4 Auri filum cylindricum, cujus diameter decimæ parti unciæ æqualis est, sustinere potest pondo 500.

5 Aurum cum Borace fusum, fit solito pallidius, refusum cum nitro colorem suum recuperat.

6 Posito quod gravitas specifica aquæ distillatæ et ad gradum 53^{m} Therm. Fahreni. calefactæ sit 1,000, gravitas specifica auri purgatissimi haberi potest 19,376.

7 Auri reliquorumque metallorum etiam purissimorum gravitates specificæ intra certos limites variæ erunt, propter et diversam gravitatem absolutam, et diversam expansionem aquæ, quâ in diversis locis et diversâ cæli temperie ponderantur.

8 Aurum cum omnibus substantiis metallicis per fusionem commisceatur.

9 Mixtura auri et ferri in minori fluit ignis gradu, quàm ferrum ipsum, et inde fit idonea ad ferri fracturas ferruminandas.

10 Mixtura auri et cupri fusilior est quàm aut aurum aut cuprum, et inde utrique fit idoneum ferrumen.

11 Aurum

11 Aurum cum Substantia quacunque Metallica colliquatum fit minus ductile; ab Argento et Cupro malleabilitas ejus minimè diminuitur, maxime autem vel potius aufertur perparvis quantitatibus Plumbi aut Stanni, vel etiam si vaporibus solùm, quos fusa emittunt, bilance non dignoscendis sit expositum.

12 Aurum ut moneta fiat, atque ut aliis usibus Oeconomicis inserviat, durius reddi solet mixturâ parvarum quantitatum aliorum metallorum, Argenti præcipue et Cupri, vel amborum conjunctim.

13 Massa quælibet auri in partes viginti quatuor, quas Ceratia vocant, dividi semper concipitur; et dicitur Aurum obryzum; Aurum caraticum tria et vicenarium, ut Aurum Ducatorum; Aurum caraticum duo et vicenarium, ut Aurum in Anglia dictum *Standard*, et sic deinceps, prout Aurum sit ab omni mixtura heterogenea illibatum, vel una, duabus, et sic deinceps partibus vigesimis quartis alterius alicujus metalli inquinatum.

14 Aurum, in integro ſuo et naturali ſtatu, hucuſque ſolubile non deprehenditur ab ullo acido ſimplici, ſulphure, alkali fixo vel volatili: ſed ab aqua regia, et hepate ſulphuris diſſolvi poteſt.

15 Aurum cum Argento colliquatum, ab acido marino, debita ſi adhibeatur Encheireſis, diſſolvi dicitur.

16 Aurum in aqua regia ſolutum, et exinde per Alkali fixum præcipitatum, ab omnibus acidis tum mineralibus tum vegetabilibus diſſolvi poteſt, nec non a ſale Alkalino volatili, et fixo, qui conficitur methodo in propoſitione 6a de Argento explicata.

17 Aurum ab aqua regia per Alkali fixum aut volatile dejectum, et leni calore ſiccatum, vocatur *Aurum fulminans*, eo quod ſive ab igne ſive affrictu incaleſcat, cum magno fragore in auras diſſipatur: Hanc autem fulminandi vim, niſi Alkali volatile vel in confectione aquæ regiæ vel in præcipitatione adhibeatur, non acquirit.

18 Pondus Auri fulminantis majus eſt pondere auri ſoluti, parte circiter quarta.

19 Aurum

19 Aurum fulminans cum displodatur, cavitates imprimit laminis metallicis non nimium crassis quibus imponitur, vel quibus supernè premitur; et non deorsum tantum, sed quaquaversum vires suas exerit.

20 Vis Elastica Auri fulminantis, dicitur esse ad vim elasticam pulveris pyrii ut 64 : 1.

21 Aurum fulminans in Sphærâ ferreâ exactissime obturatâ inclusum, ac igni expositum, non disploditur; in simili casu pulveris pyrii facta est explosio, et sphæra simul disrupta invenitur.

22 Aurum fulminans aqua sæpius lavatum, cum oleo vitrioli tritum, cum sulphure fusum, vel ab alkali fixo lixatum, vim suam fulminantem amittit.

23 Aurum nec per calcinationem cum vel sine additione, nec per solutionem in aqua regia, nec per sublimationem, nec per explosionem, nec per ullam aliam methodum hucusque repertam, in partes dissimiles resolvatur.

24 Aurum in aqua regia solutum cutem et plures substantias animales ac vegetabiles rubro vel purpureo colore tingit; debita facta evaporatione, in crystallos concrescit rubras; et quacunque methodo metallico suo aspectu sit privatum, et ad pulveris speciem redactum, colorem magis minusve rubicundum plerumque adipiscitur.

25 Aurum, metallorum densissimum, cum vitro puro crystallino colliquefactione confusum, vitri densitatem adaugendo, aptum illud reddit ad reflectendos radios minime refrangebiles, et semper vitrum præbet rubro colore pellucidum.

26 Aurum a menstruo suo extrahitur, atque per aliquod tempus suspensum tenetur, Oleis Essentialibus; facillime autem separatur Æthere vitriolico: et cum unicum sit metallum cui hæc proprietas competit, si cum cæteris vel minima quantitate commisceatur, hoc indicio deprehendi potest.

27 Aurum in aqua regia solutum inde præcipitari potest (si multa aqua diluatur solutio) vel laminis Stanni, vel solutione Stanni in eodem menstruo factâ, sub forma pulveris coccinei, qui vulgo vocatur *Cassii purpureum Magisterium.*

28 Una Auri solutionis guttula, per aliquot aquæ uncias diffusa, Stanni interventu colorem purpureum toti aquæ conciliat; et sic ab omnibus Substantiis metallicis, quibus admisceatur, facillime dignoscatur.

26 Hepar Sulphuris cum Auro liquatum illud facile et adeo penitus dissolvit, ut Aurum una cum Hepate filtrum permeans, in aqua suspensum maneat.

30 Aurum ab omnibus metallicis substantiis, Platina excepta, optime purgatur fusione cum Antimonio; ab omnibus præter Argentum et Platinam cupellatione cum plumbo; ab Argento solutione in aqua regia; a Platina, et minutis portiunculis cupri, aliorumve metallorum quæ Catini cinericii vim haud raro effugiunt, per

præcipitationem ab aqua regia; interventu vitrioli viridis.

CAP. XV.

De Platina five Auro albo.

1 PLATINA est metallum perfectum, fixitate, ductilitate, et gravitate specifica auro vix secunda; cæteris metallis in igne longe minus fusilis, et ferro forsan excepto durior; colore argento obfuscato similis.

2 Platina, in igne vehementissimo quem furni et crucibula optima sustinere possunt anteaquam in vitrum liquescunt, non funditur, sed pondere aliquantulùm augmentatur: Hæc ponderis augmentatio adhæsioni forsan ferri, vel metalli cujuslibet imperfecti, quod per calcinationem pondere augetur, referri debet.

3 Platina, radiis solaribus condensatis in foco speculi concavi, cujus diameter

meter æqualis erat 22 unciis, et focalis diſtantia 28 unciis, expoſita, ex parte in fumum erat acta, ex parte fuſa in corpus album, ſplendeſcens, admodum malleabile.

4 Platina non ſolvitur ab acido vitriolico aquoſo aut concentrato, frigido aut ebulliente; nec ab acido marino, viâ aut humidâ aut ſiccâ; nec ab acido nitri communi aut fumante; nec a ſulphure communi; nec ab antimonio crudo: et hinc ab omnibus ſubſtantiis metallicis, auro excepto, diſtinguitur.

5 Platina ab aqua regia et hepate ſulphuris, inſtar auri, diſſolvi poteſt.

6 Platina in aqua regia ſoluta eſt coloris aurei, aut fuſci, in rubedinem vergentis, prout ſolutio eſt ex parte vel penitus ſaturata: Hæc ſolutio evaporatione concreſcit in cryſtallos rubentes; ſolidis animalium partibus, lamellis vel ſolutioni ſtanni, colorem rubrum aut purpureum, lavatione aquæ haud eximendum, non impertit; a ſale ammoniaco ex parte præcipitatur Platina, ſed nec a vitriolo viridi, nec ab

Alkali

Alkali fixo minerali; ab Oleis essentialibus, Æthere vitriolico, aut Spiritu Vini rectificato, a menstruo suo non separatur, et hinc ab ipso auro distinguatur; minimaque hujus vel illius metalli portiuncula, in mixtura quavis metallica ex ambobus conflata, his præcipue similibusque indicibus facillime dignoscatur.

7 Platina ab aqua regia per Alkali volatile præcipitata, exsiccata et igni exposita, non fulminat, et sic etiam ab auro discrepat.

8 Platina a menstruo suo præcipitata, cum vitro contuso mixta, et igni violentiori per longum tempus exposita, nec cum vitro fusione conjungi, nec colorem ullum ei communicare, videtur.

9 Platina cum omnibus substantiis metallicis per fusionem coit: si cum Aurichalci pari pondere fundatur, massa conflabitur dura quidem et fragilis, quæ polituram eximiam suscipit, et nitorem suum diu conservat.

10 Platina cum Plumbo aut Bismutho fusa, et cupello subjecta, igne

vix

vix vehementiſſimo ab iſtis metallis adeo penitus liberari poteſt, ut fiat malleabilis.

11 Aurum cum Platina colliquatum fit durius et in igne ſimul minus fuſile, quod in mixtione ſua cum aliis metallis non evenit.

12 Mercurius, qui majorem habet Affinitatem cum Auro et Argento quam cum Plumbo, habet etiam majorem cum Platina; ſed minorem cum Platina quam cum Auro.

13 Platina majorem habet Affinitatem cum plumbo quam cum ferro.

14 Platina, Auri inſtar, minorem habet Affinitatem cum aqua regia quam aut Zincum, aut Ferrum, aut Cuprum, aut Stannum, aut Argentum vivum.

F I N I S.